Water Conserving On-Site Wastewater Treatment Systems —

Recommended Standards and Guidance for
Performance, Application, Design, and Operation & Maintenance

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Health

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Preface

The recommended standards contained in this document have been developed for statewide application. Regional differences may, however, result in application of this technology in a manner different than it is presented here. In some localities, greater allowances than those described here may reasonably be granted. In other localities, allowances that are provided for in this document may be restricted. In either setting, the local health officer has full authority in the application of this technology, consistent with Chapter 246-272 WAC and local jurisdictional rules. If any provision of these recommended standards is inconsistent with local jurisdictional rules, regulations, ordinances, policies, procedures, or practices, the local standards take precedence. Application of the recommended standards presented here is at the full discretion of the local health officer.

Local jurisdictional application of these recommended standards may be:

1) **Adopted as part of local rules, regulations or ordinances—**When the recommended standards, either as they are written or modified to more accurately reflect local conditions, are adopted as part of the local rules, their application is governed by local rule authority.

2) **Referred to as technical guidance in the application of the technology—**The recommended standards, either as they are written or modified to more accurately reflect local conditions, may be used locally as technical guidance.

Application of these recommended standards may occur in a manner that combines these two approaches. How these recommended standards are applied at the local jurisdictional level remains at the discretion of the local health officer and the local board of health.

The recommended standards presented here are provided in typical rule language to assist those local jurisdictions where adoption in local rules is the preferred option. Other information and guidance is presented in text boxes with a modified font style to easily distinguish it from the recommended standards.

Acknowledgements—

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- Composting Toilet Task Force
- Geoflow, Inc.
- Lombardi and Associates
- Orenco Systems, Inc.
- Puget Sound Water Quality Action Team
- Sun-Mar Corporation
- Washington State On-Site Sewage Association (WOSSA)
- Washington State On-Site Sewage Treatment Technical Review Committee (TRC)
- Waste Water Systems, Inc.
- Waste Water Technologies

Introduction / Framework

This document presents recommended standards and guidance for the use of water-conserving on-site sewage systems. Generally, water conservation as part of an on-site sewage system can be obtained by two processes: 1) reduce the volume of water used (to transport wastes through piping), and 2) reuse wastewater for other non-potable uses, such as sub-surface irrigation of plants, shrubs, trees, and turf. These processes may be used separately or in combination.

It is helpful in presentation of this material to identify some terms that are commonly used:

> **Combined Wastewater** — Waste from laundry, sinks, showers, toilets, etc. co-mingled and delivered to a sewage treatment system designed to treat and dispose of the entire wastewater flow.
>
> **Greywater —** Waste from laundry, sinks, showers. Does not include wastewater from toilets.
>
> **Blackwater —** Waste from toilets (may include additional water to aid waste transport through the pipes).

All of these categories of wastewater present significant concerns for appropriate treatment and disposal in order to protect public health.

When combined wastewater is separated into greywater and blackwater waste streams, options for conserving water emerge. If waterless toilets are employed for the blackwater side, water commonly used to transport waste in combined wastewater flows is conserved. The volume of water conserved can reach 50% of that commonly used in combined wastewater flow. Correspondingly, septic tank and drainfields for treatment and disposal of greywater can be smaller than those for combine wastewater flow systems. If subsurface irrigation is incorporated in the sewage system design and the site landscaping plan, further water savings can be attained when greywater is used instead of potable water for outdoor landscape irrigation.

When developing a water conserving on-site sewage system, it is critical that both waste streams, greywater and blackwater, are properly treated and disposed. For example, use of a waterless toilet requires a means to properly treat and dispose of the remaining greywater. Greywater treatment may be achieved through an on-site system or public sewer.

In another example, blackwater treatment and disposal could be provided by a conventional septic tank and drainfield system, an alternative water-carried sewage system, or public sewer. A greywater system could provide for greywater reuse via subsurface landscape irrigation, saving potable water for other purposes.

Document Divisions

This document is divided into three Sections and an Appendix.

Section A [Waterless Toilets] — Describes the recommended standards for on-site sewage treatment and disposal using waterless toilets.

Section B [Greywater Systems] — Describes the recommended standards for on-site sewage treatment and disposal of greywater, with enhancements to optimize subsurface irrigation potential as a means of greywater reuse.

Section C [Subsurface Drip Dispersal Systems] — Describes a technology relatively new to Washington State — subsurface drip dispersal system — and its integration into a greywater treatment system. This new technology may ultimately have application with combined wastewater.

Appendix — An appendix provides guidance for landscape planning for subsurface irrigation with greywater, drawings, tables, a glossary of terms and other useful references.

<u>Section A</u> — Waterless Toilets

There are currently four types of waterless toilets approved for use in Washington State: 1) composting toilets, 2) incinerating toilets, 3) vault toilets, and 4) pit toilets (Note: many settings are not be suitable for the use of pit toilets). Each is summarized as follows:

Composting Toilet [Subsection A1]— A system designed to store and compost (primarily by unsaturated, aerobic microbial digestion) human excrement (human urine and feces) to a stable soil-like material called "humus." These systems are commonly designed to accommodate fecal and urinary wastes (human excrement), toilet paper and small amounts of organic carbonaceous material added to assist their function.

Incinerating Toilet [Subsection A2] — A self-contained unit that reduces non-water-carried human excrement (human urine and feces) to ash and evaporate the liquid portion. Wastes are deposited directly into a combustion chamber and are incinerated upon a signal. The process is fueled by LP or natural gas, fuel oil or electricity.

Vault Toilet [Subsection A3] — An on-site sewage system that incorporates 1) a structure enclosing a toilet above a water-tight (preventing liquid infiltration into the soil) storage chamber for human waste, 2) the services of a sewage pumper/hauler, and 3) the off-site treatment and disposal for the sewage generated. Portable chemical toilets are not included in this category.

Pit Toilets [Subsection A4]— An on-site sewage disposal unit consisting of a structure overlying an excavation not exceeding five feet in depth in which human excrement (human feces and urine) is directly deposited for permanent placement in the ground. Pit toilets, due to site and soil considerations, have very limited application.

Recommended standards and guidance for Performance, Application, Design, and Operation & Maintenance of waterless toilets are described in Sub-Sections A1 – A4 of this Section.

Subsection A1 – Composting Toilets

Introduction — A composting toilet is a system designed to store and compost (primarily by unsaturated, aerobic microbial digestion) human excrement (human urine and feces), ideally to a stable soil-like material called “humus.” (Note: See “Managing the Product of Composting Toilets” which is found at the end of this Sub-Section). These systems are commonly designed to accommodate fecal and urinary wastes (human excrement), toilet paper and small amounts of organic carbonaceous material added to assist their function.

The owner/operator of a composting toilet system should be aware that the successful operation of these systems requires a consistent diligence to the details of the composting process. Only individuals, private organizations or government agencies who are willing to accept the responsibility of composting human excrement should be involved. If composting toilet systems are not routinely monitored and maintained as required, or improperly operated, they will fail and the owner will be faced with disposing of unprocessed human excrement.[1] Owners/operators of composting toilet systems should also be fully aware of how the final composted product may either be used for beneficial purposes or disposed according to federal and state sludge/biosolids laws and regulations, which are described in this document.

The main components of a composting toilet are[2]:

- A composting chamber connected to one or more dry toilets;
- An exhaust system (often fan-forced) to remove odors, carbon dioxide, water vapor, and the by-products of aerobic decomposition;
- A means of ventilation to provide oxygen (aeration) for the aerobic organisms in the composter;
- A means of draining and managing excess liquid and leachate;
- Process controls, such as mixers, or access doors to the composting materials for manual mixing, to optimize the composting process; and
- An access mechanism for removal of the end product

Composting toilet systems include various types and configurations, which include[2]:

- Manufactured Systems vs. Site Built Systems:
    - Manufactured (proprietary systems);
    - Site-Built (generic or public domain systems);
- Self-Contained Systems vs. Centralized or Remote Systems:
    - Self-contained systems (the toilet seat and composting chamber are one unit)
    - Centralized or remote systems (the toilet seat connects to a composting chamber that is located somewhere else);
    - Batch Systems vs. Continuous Systems
        - Batch composters (multiple chamber systems using two or more interchangeable composting chambers, where one is filled at a time and allowed to cure, while another chamber fills)
        - Continuous composters (single chamber into which excrement is added to the top, and the end product is removed from the bottom);

- Active Systems vs. Passive Systems
  - Active (in which the composting material is actively manipulated, e.g., aeration, mixing, heating, resulting in a greater composting efficiency and volume reduction)
  - Passive (in which the material is collected and allowed to decompose or molder in cool environments without active process control (heat, mixing, aeration)[2]

Adapted with permission from Del Porto and Steinfeld (See reference 2)

Composting toilets also have varying use patterns that should be recognized. For example, three types of composting system use patterns are identified by the National Sanitation Foundation[3] as follows:

- Residential systems - those systems that are intended for use in home settings, apartment complexes and other settings that receive daily residential use;
- Day-use park systems – those systems that are intended for use in day parks, roadside stops, and other similar settings; and
- Cottage systems – those systems that are intended for occasional use. Cottage settings can include vacation homes, weekend cottages, and cabins.

In general, the composting chamber should be constructed to separate the solids from the liquids and produce a stable, humus material[2]. NSF *International*, in its testing and certification protocol, has established that the solid end product shall not produce an objectionable odor immediately following removal from the system, exceed a moisture content of 65%, or contain fecal coliform levels in excess of 200 most probable number (MPN) per gram[3].

1. Composting Toilet Performance Standards

1.1. **Listing —**Specific proprietary composting toilet systems are listed by the DOH on its *List of Approved Systems and Products*[4] when the manufacturer or designated manufacturer representative demonstrates that the product meets or exceeds the appropriate testing requirements. The DOH does not review or list non-proprietary public domain composting toilet systems.

1.2. Testing —

1.2.1. Proprietary Products

1.2.1.1. Proprietary products are those systems or components thereof that are held under patent, trademark, or copyright.

1.2.1.2. Proprietary products must be tested by a qualified party independent from the manufacturer.

1.2.1.3. Composting Toilets of proprietary design must be tested according to the specifications and protocols established in the American National Standard/NSF International Standard for Wastewater Technology – Non-Liquid Saturated Treatment Systems [ANSI/NSF 41 – 1998] (NSF) or the most current version of that standard[3].

1.2.1.4. To be listed on the *DOH List of Approved Products and Systems*, DOH does require that NSF standards be met, but does not require manufacturers to have testing and analysis of their product, or on-going product certification, by NSF. Other testing facilities may be reviewed and approved by DOH, on a case-by-case basis.

1.2.2. Public Domain Systems

1.2.2.1. A public domain composting toilet system is a composting toilet system or design which is not protected by patent, trademark, or copyright, and is therefore available to be used by any member of the public without cost or obligation to a patent, trademark, or copyright holder.

1.2.2.2. Specifications, where provided in this document, have been identified as appropriate for composting toilet systems. Testing is not required of public domain composting toilets when designed, constructed, operated and maintained according to the specifications where provided in this document.

Testing Exclusion – Public Domain Composting Toilets

This document excludes the requirement for testing of composting toilets if designed, constructed, and operated according to the specifications provided in this Recommended Standards and Guidance (RS&G) document. However, LHJs may require that any permitted system be monitored for performance, and that these performance data be submitted to the DOH. According to the state on-site rule, the LHJ must notify the DOH about all compost toilets that it approves. If systems are found to be failing by the LHJ, the LHJ must also notify the DOH [WAC 246-272-04001(3)].

2. Composting Toilet Application Standards

2.1 **Permitting –** The local health officer or department shall only permit installation of alternative systems for which there are alternative system guidelines (referred to as "Recommended Standards and Guidance,") or a proprietary device if it appears on the DOH *List of Approved Systems and Products*.

2.1.1 **RS&G** - Recommended Standards and Guidance have been approved by the DOH for composting toilets.

2.1.2 **Listed Products** - For proprietary products, only the specific models listed by the DOH on its *List of Approved Systems and Products* are approved. Others in manufacturers' product-lines are not approved for use in Washington State. If in doubt, check with DOH for current listing information.

2.1.3 **Permits Required** - Installation, and if required, operational, permits must be obtained from the appropriate local health officer prior to installation and use.

2.2 **Use Criteria —** Composting toilets may be used where occupancy or use patterns are full-time or part-time, permanent or temporary, commercial or residential.

2.2.1 Where potable water <u>is</u> provided and greywater <u>is</u> generated, composting toilets may only be used when combined with an approved on-site greywater treatment and disposal system, or public sewage system.

2.2.2 Where potable water <u>is not</u> provided and greywater <u>is not</u> generated, composting toilets may be used without an approved on-site greywater treatment and disposal system or public sewage system.

2.3 **Influent Characteristics —** Washington state currently approves composting toilets that do not use flush water to transport excrement, toilet paper and additive from the toilet to the composting chamber. Only urine, feces, toilet paper and carbonaceous additive are introduced into the composting toilet system.

2.4 **Composting Toilet Size / Model Selection —**

2.4.1 For DOH listed proprietary composting toilets, follow the number of users or uses per day identified by the manufacturer.

2.4.2 For non-proprietary composting toilets, the system must be designed to accommodate the solid and liquid material.

Sizing Composting Toilets

There is no simple formula for determining the ideal size for a composting toilet system. Factors to consider when sizing a system include the number of individuals who would be using the system, the frequency and kind of use (e.g., residential or continuously used systems, day-use parks systems, cottage or intermittently used systems), and the degree that environmental factors will be managed (e.g., aeration, moisture content, temperature, carbon-nitrogen ratio, and the presence of process controls), which would significantly impact the effectiveness and rate of the composting process and the ultimate volume of the composting material in the composting chamber.

The composting process can result in a significant volume reduction in a relatively short time period under ideal composting conditions. However, under less ideal composting conditions, this would not be the case, and a larger storage capacity would be necessary. For instance, moldering toilet systems (those systems which support psychrophilic organisms, whose optimum temperature is above 41F and below 68F) are sized much larger than mesophilic composting systems (those systems which support mesophilic organisms, whose optimum temperature is from 68F to 112F) to compensate for their reduced processing time[1]. A composter subjected to temperatures of 41F or less will only accumulate excrement, toilet paper and additive until the temperature rises. That is why composter manufacturers state their capacities at 65F (comfortable room temperature of an average human-occupied space)[2].

Studies conducted in a northern European community have shown that the average adult will produce about 40.6 fluid ounces (1.2 liters) of urine and 20.3 fluid ounces (.6 liters) of feces daily. Performance rating organizations such as the National Sanitation Foundation take into account "population equivalents" (p.e.), which are the average number of excrement events produced by an average adult person in one 24 hour period. For this standard, one p.e. is defined as 1.2 fecal events and four urine events per person per day. It is important to remember that the ratio of urine to feces volume varies in different settings. In a day-use public facility, there will be a much higher ratio of urine to feces (e.g., 10:1), but in a residential setting, a ratio of from 3:1 to 4:1 is common[2].

These factors should be considered when sizing a composting toilet system for a particular need.

2.5 **Installation —**

2.5.1 DOH listed proprietary composting toilets must be installed according to the manufacturer's instructions in compliance with state and local requirements.

2.5.2 Public domain composting toilets must be installed in a manner that is consistent with all state and local requirements.

2.5.3 Composting toilets must be installed by a person authorized by the local health officer.

2.6 **Horizontal Separation —**

2.6.1 For composting toilets installed entirely within a structure or a service vault, there are no specific set-back requirements.

2.6.2 For composting toilets where a part of the unit is installed directly in or on the ground, or on the exterior of or below the structure served (e.g., a crawl space), the setback requirements are the same as prescribed for holding tanks in WAC 246-272-09501, except that the "building foundation" provision of Table 1 [Minimum Horizontal Separations] shall not apply.

2.7 **Vertical Separation —**

2.7.1 For composting toilets installed entirely within a structure or a service vault, there are no specific vertical separation requirements.

2.7.2 For composting toilets that discharge liquids to a subsurface soil absorption system, the vertical separation requirements of Chapter 246-272 WAC would apply (see Section 4.10 of this document for further information).

2.8 **Suitable Soils —**

2.8.1 Installation of composting toilets is not dependent upon soil type, as the soil is not used to treat or dispose of chamber contents.

3. **Composting Toilet Design Standards —**

3.1. **Access Ports —** Access ports must be sized and located to facilitate the installation, removal, sampling, examination, maintenance, and servicing of components and compartments that require routine maintenance and inspection. Access ports must also be sized and located to allow for the sanitary management of the composting material to facilitate the aerobic composting process, as necessary. Maintenance of the system shall not require the user to completely enter the treatment or storage containers. The access ports shall be of sufficient size and located so as to allow for the following:

- Periodic cleaning or replacement of components as necessary;

- Visual inspection and sampling as specified in the operation and maintenance manual;

- Raking or turning of the composting material to facilitate the composting process, as necessary;

- Removal (manually or by pumping) of collected residuals and end products as required in the operation and maintenance manual.

3.2 Materials

3.2.1 All construction materials used must be durable, easily cleaned and impervious to strong acid or alkaline solutions and corrosive environments. Examples of such material are styrene rubber, polyvinyl chloride, and fiberglass. All metal surfaces must be corrosion-resistant.

3.2.2 Dissimilar materials may be used in mating parts, but must have galvanic compatibility or be joined with insulating fittings.

3.2.3 All electrical work-must comply with applicable national, state and local codes. All electrical controls and other electrical components must be approved by Underwriters Laboratory (UL) or equivalent.

3.3 Reliability and Structural Integrity

3.3.1 Device components must demonstrate adequate resistance to adverse influences anticipated in the typical use environment. This environment must include usual vibration, shock, climatic conditions and cleaning procedures as prescribed by the manufacturer. All component parts must be free of nonfunctional, rough or sharp edges, or other hazards that could cause injury to persons adjusting, servicing or using the device.

3.3.2 The system, when filled or empty, shall maintain its structural integrity when subjected to earth and hydrostatic pressures.

3.3.3 The system, including all joints, seams, and components shall preclude infiltration of ground water into the system and exfiltration of liquid out of the system.

3.4 Design Criteria

3.4.1 Components that require periodic maintenance shall be easily accessible and easily replaceable.

3.4.2 The devices must be capable of accommodating full or part-time usage without accumulating excess liquids when operated at the design rated capacity. The devices must be designed such that the blockage of vents or leakage of liquids through other than standard discharge orifices is reasonably avoidable.

3.4.3 Continuous ventilation of the storage or treatment chamber must be provided to the outside. Venting connections must not be made to room vents or to chimneys. All vents must be designed to control flies and other insects from entering the treatment chamber. Vent conduits and pipes must be adequately insulated to prevent the formation of condensed vapors onto their interior.

3.4.4 Gas emitted from the vent system shall be non-offensive at ground level, and there shall be minimal offensive odors at the toilet seat emanating from the composting chamber.

3.4.5 In general, components in which biological activity is intended to occur should be insulated, heated, or otherwise protected from low temperature conditions, in order to maintain the wastes during treatment remain at temperatures conducive to the composting process. Systems that will operate during periods in which there is insufficient heat for composting to take place should be designed recognizing that the systems will operate not as composting toilets, but as excrement storage units during those periods of time.

The Influence of Temperature on the Composting Process[2]

Four temperature ranges should be recognized when considering the composting process:

- *Below 42F – little to no active microbial processing takes place. Within this temperature range, the system will only serve as a storage vessel for excrement, toilet paper, and additives.*

- *From 42F to 67F – psychrophilic microorganisms dominate (e.g., actinomycetes and fungi)) which results in a moldering processing. Moldering toilets are designed to operate within this temperature range. Because the composting process is so much slower in this range, larger composter vessel sizes may be needed to compensate for the slow volume reduction of the composting mass.*

- *From 68F to 112F – mesophilic bacteria dominate. This is the typical temperature range for most composting toilets.*

- *From 113F to 160F – thermophilic bacteria dominate (atypical of most compost systems unless assisted by an external heating system)*

3.4.6 Sufficient distance of air space must be provided to separate, at all times and under any conditions, deposited wastes from the user.

3.4.7 Means must be provided to keep separate waste undergoing treatment from finished end products.

3.4.8 Composting toilet systems shall be designed and managed to control vectors (e.g., insects).

Vectors Management

Vectors (e.g., flies, beetles, mites, and other arthropods) will be attracted to human excrement to feed or reproduce, as conditions allow. Vectors that have been in contact with excrement can then carry pathogens from the composting chamber and bring them into contact with humans through various pathways (e.g., food contamination by flies). It is therefore important to control vector populations from entering the composting chamber. Composting toilet design and management considerations include[2]:

- *Screen ventilation openings (Note: screens may become clogged and require periodic cleaning);*
- *Seal cracks and openings (a smoke test can reveal them);*
- *Apply environmentally benign insect repellents, such as pyrethrins and diatomaceous earth;*
- *Capture insects with insect strips*
- *Avoid putting kitchen scraps into the composter.*

Adapted with permission from Del Porto and Steinfeld (See reference 2)

3.4.9 Overflow (excess leachate) discharged from composting toilets must be treated and disposed in a manner consistent with Chapter 246-272 WAC.

Leachate Management

Leachate is the liquid that has infiltrated through the composting mass and which accumulates at the bottom of the composting vessel. Options for leachate management include[2]:

- *Automatic pumping (e.g., an electric sewage pump) or manual pumping (e.g., a marine bilge pump) to a storage chamber or vessel;*
- *Assisted evaporation via a mechanism such as an electric heating system (natural evaporation is not recommended because of its inability to effectively evaporate liquids in a composting system, which would result in accumulation or overflow of liquids in the bottom of the composter, and saturated, anaerobic conditions.)*
- *Drainage by gravity to a storage tank for pumping and management by a septage pumper, or to an on-site sewage system approved by the local health officer in accordance with Chapter 246-272 WAC.*

Adapted with permission from Del Porto and Steinfeld (See reference 2)

4. **Composting Toilet Operation & Maintenance Standards —**

4.1. **General Standards —**

4.1.1. The owner / operator of the on-site sewage system must notify the local health department when the unit fails to function properly.

4.1.2. The residence or facility owner is responsible for assuring proper operation and providing timely maintenance of the composting toilet.

4.1.3. For DOH listed proprietary composting toilets, the authorized proprietary product representative must instruct, or assure that instruction is provided to, the residence or facility owner in proper operation of the composting toilet. Emphasis must be placed on those aspects related to operating and maintaining the composting toilet within its normal operating range.

4.2. **Owner's Manual —** Each composting toilet system must be accompanied by a comprehensive owner's manual developed / assembled by the system designer and/or installer that addresses all components of the entire on-site wastewater system. The owner’s manual shall include specific instruction for system installation, operation and maintenance, and troubleshooting and repair. The manual may be a collection of individual system component manuals. For listed proprietary systems, the authorized proprietary product representative must provide a manufacturer-prepared manual to the sewage system designer for the system owner. The manual(s) must be written to be easily understood by the owner/operator and must include, at a minimum:

4.2.1. The system's primary functional components, equipment manufacturer(s) and model designation, as applicable;

4.2.2. A statement designating treatment capacity (such as number of users or uses per day).

4.2.3. A functional description of system operation, including diagrams illustrating basic system design and flow-path;

4.2.4. A clear statement of examples of the types of waste that can be effectively placed and treated in the system;

4.2.5. A list of household substances that, if discharged to the system, may adversely affect the system, the process, or the environment;

4.2.6. Comprehensive, site specific operating instructions that clearly describe proper function of the system, and the operating and maintenance responsibilities of the owner and authorized service personnel, and service-related obligations of the manufacturer(s), if applicable;

4.2.7. Requirements and recommended procedures for the periodic removal of residuals from the system;

4.2.8. Site-specific requirement for compliance with local, state and federal regulations for the handling and final disposition of end products from the system;

4.2.9. A course of action to be taken if the system is to be used intermittently or if extended periods of non-use are anticipated, or if subjected to an electrical power interruption;

4.2.10. Detailed methods and criteria to be used to identify system malfunction or problems;

4.2.11. A statement instructing the owner to reference the system data plate in the event that a problem arises or service is required, if applicable

4.2.12. List of replacement parts;

4.2.13. Electrical schematics for the system if not appearing on the system itself, as applicable;

4.2.14. Specifications pertaining to the energy source and energy required for proper operation of the composting toilet; and

4.2.15. The name and telephone number of an appropriate representative to be contacted in the event that a problem with the system occurs.

4.3. **Installation Manual —** Composting toilet manufacturers must provide comprehensive and detailed installation instructions to authorized representatives. Manufacturers of other system components must make available to the sewage system designer and/or installer similar documentation. The manual must be written to be easily understood by the installer and must include, at a minimum:

4.3.1. A numbered list of system components and an accompanying illustration, photograph, or print in which the components are respectively identified;

4.3.2. Design, construction, and material specifications, for the system's components;

4.3.3. Wiring schematics for the system's electrical components;

4.3.4. Off-loading and unpacking instructions including safety considerations, identification of fragile components, and measures to be taken to avoid damage to the system;

4.3.5. A process overview of the function of each component and the expected function of the entire system when all components are properly assembled and connected;

4.3.6. A clear description of system installation requirements including plumbing and electrical power requirements, ventilation, air intake protection, bedding, hydrostatic displacement protection, water tightness, slope, and miscellaneous fittings and appurtenances;

4.3.7. A sequential installation procedure from the residence out;

4.3.8. Repair or replacement instructions in the event that a system has flaws that would inhibit proper functioning and a list of sources where replacement components can be obtained; and

4.3.9. A detailed start-up procedure.

4.4. **O&M Service Recordkeeping and Reporting —** O&M service record keeping and reports required for the local health jurisdiction must specify:

- What data are to be reported;
- To whom the reports are to be submitted;
- The format for presenting information; and

- The frequency of reporting.

4.5. System Operation and Maintenance —

4.5.1. In general, components in which biological activity is intended to occur should be insulated, heated, or otherwise protected from low temperature conditions, in order to maintain the wastes during treatment remain at temperatures conducive to the composting process.

4.5.2. Systems that will operate during periods in which there is insufficient heat for composting to take place should be designed recognizing that the systems will operate not as composting toilets, but as excrement storage units during those periods of time.

Elements of the Composting Process[2]

In general, composting is the controlled aerobic biological decomposition of moist organic matter to produce a soil conditioner (humus) (See "Managing the Product of Composting Toilets below). Because composting requires oxygen, the organic material being composted cannot be immersed in liquids (saturated).

The primary microorganisms responsible for the composting process are bacteria, actinomycetes, and fungi. Other microoganisms such as yeasts and algae also may play a role. Soil animals, such as protozoa, amoeba, nematodes, earthworms and arthropods, also perform major roles by degrading surface litter, consuming bacteria, and assisting in aeration.

Certain environmental factors must be addressed to maximize the composting process. These include:

Oxygen – the aerobic organisms responsible for the composting process require free atmospheric or molecular oxygen to survive. Without oxygen, they will die and be replaced by anaerobic microorganisms which will slow the composting process and generate odors and potentially flammable methane gas. For composting toilets to work most effectively, the materials being composted should be unsaturated with liquids, and have a loose texture to allow air to circulate freely within the pile. This can be accomplished by

- *Adding bulking agents, such as wood chips, shavings commonly available as pet bedding, coconut fiber, cottonwood, stale popped popcorn, etc., to increase pore spaces to allow the influx of oxygen into the mass, and the release of heat, water vapor and carbon dioxide from the composting mass. Earthworms also assist this process. Note: users are cautioned not to use bulking agents which may either mat or introduce bugs into the system, such as leaves. Users are also cautioned not to use certain wood such as cedar, or redwood as a bulking agent due to the difficulty of decomposition.*

- *Maintaining adequate airflow through the material by providing proper ventilation (e.g., pressurized air, using convection or forced air by a fan) and/or by frequently mixing, either manually or by automatic processes);*

Moisture Content – In optimum conditions, the composting material has the consistency of a well-wrung sponge – about 45 percent to 70 percent moisture. When below 45 percent, there is not sufficient moisture for the microorganisms to function, and above 70 percent, saturated conditions begin to develop, and oxygen depletion becomes a limiting factor.

Temperature – (See the guidance discussion on temperature in the section above)

Carbon to Nitrogen (C:N) Ratio – Microorganisms require digestible carbon as an energy source for growth, and nitrogen and other nutrients for protein synthesis. When measured on a dry weight basis, an optimum C:N ratio for aerobic bacteria is about 25:1. Although important, the significance of the C:N ratio in composting toilets is often overstated. The primary reason to add carbon material such as wood chips to a composting toilet is to create air pockets in the composting material. However, a small handful of dry matter per person per *day or a few cups every week is a good rule of thumb to maintain a helpful C:N ratio, absorb excess moisture, and maintain pores in the composting material.*

Adapted with permission from Del Porto and Steinfeld (See reference 2)

Pathogens

Composting toilets serve to prevent human exposure to human excrement and to store it in aesthetically acceptable conditions until it can be safely removed for disposal or reuse (See "Managing the Products of Composting Toilets, below). Two primary factors affecting the survival of human pathogens in composting toilets are temperature and time. In general, pathogens will die off when subjected to temperatures above 122^{0} F for a sufficient length of time. However, achieving such temperatures during the composting process relies on ideal conditions, including adequate air supply, moisture content, and C:N ratio. Such temperatures are rarely achieved during the composting of human excrement in a composting toilet. Pathogens will also die- off with time, which is based on the retention time in the unit. Most bacteria, viruses, and protozoans will die-off within several months. However, certain helminth (e.g., Ascaris lumbricoides – the common round worm) and protozoan oocyst-producing species (e.g., Cryptosporidium parvum – a type of parasite that causes diarrhea) are highly resistant to environmental stresses and will survive for longer periods of time. In addition, unless fresh excrement is entirely separated from finished product in the unit, contamination of the finished product can occur [5,6]. For these reasons, care should be observed when land application of the residual product is considered. The product of a composting toilet is generally not suitable for application to a lawn or garden. (Note: See "Managing the Products of Composting Toilets" below).

4.6 **Disposition of the Final Product –** Removal, beneficial use or disposal of composted and liquid materials must be done in a manner that meets federal, state and local regulations. See "Managing the Product of Composting Toilets" below.

Managing the Product of Composting Toilets

Part A – Definitions

The product of a composting toilet falls under federal and state sewage sludge regulations (sewage sludge is referred to as "biosolids" in Washington state). Technical elements of the federal sewage sludge program are addressed in 40 CFR Part 503. Washington state's biosolids program is addressed in Chapter 173-308 WAC, with its authority deriving from Chapter 70.95J RCW. By law, the Washington state program must meet or exceed federal minimum standards in order for the state to eventually obtain delegation of federal authority.

Under both the federal sewage sludge program and the Washington state biosolids program, the product of composting toilets qualifies as sewage sludge, which is classified as "domestic *septage" by the U.S. Environmental Protection Agency and the Washington State Department of Ecology.*

Definitions in the state program differ slightly from that of the federal program in that the term "domestic septage" is broken into three classes. Under state rules, septage from a composting toilet could be either Class I or Class II domestic septage:

- *Class I is liquid or solid material ... that has had a sufficiently long residency time to be considered largely stabilized...*
- *Class II is liquid or solid material removed from portable toilets ... or other similar holding systems...*

Therefore, under both the federal and state sewage sludge/biosolids programs:

- *Composting toilet residuals are subject to regulation under federal and state biosolids programs*
- *The product of a composting toilet may be regulated as septage, which is a form of sewage sludge/biosolids*

Part B – Management Options

Neither the federal or state sewage sludge/biosolids rules provide any exemptions or allowances for small quantity generators from any parts of the rules. As such, the product from small composting toilets must be managed by the same regulations, and applied with the same degree of stringency, as sewage sludge/biosolids generated by the largest of generators. Because the Washington state program must, by law, meet or exceed the stringency of the federal program, the state cannot relax these requirements for the product of composting toilets unless rule changes are made at the federal level.

That said, under the state's biosolids regulations, domestic septage can be managed either as 1) sewage sludge/biosolids (e.g., as sewage sludge/biosolids from a treatment plant) or 2) domestic septage. Although allowed, managing the product of composting toilets as sewage sludge/biosolids is probably not practical for a homeowner because of the stringent regulatory requirements associated with that management option. A more practical approach is to manage composting toilet residuals as domestic septage, which would include the following elements:

- *Domestic Septage – Class I – Compost toilet residual is assumed to be Domestic Septage – Class I (if it is determined that the material has had a sufficiently long residency time to be considered largely stabilized). [WAC 173-308-080 (Definitions)]*

- *Area of Application – Compost toilet residuals may only be applied to certain types of land, typically agricultural or forest land, but not to a "public contact site," a "lawn" or "home garden" area [WAC 173-308-270 (1)]. Note: When applied to forest or pasture land, the site management and access restrictions of WAC 173-308-080(5) must be be met as applicable.*

- *Screening - Recognizable materials are removed from the residuals, or not deposited into the system to begin with. [WAC 173-308-270(2)]*

- *Pathogens –The site management and access restrictions of WAC 173-308-270 (5)(a)(i)-(ix) (5)(b)(i)-(iv) must be met as applicable. [WAC 173-308-080(3)(b)] (Note: pH adjustments may be allowed as an alternative to the site management and access restrictions noted above if approved through the state's biosolids permit program, although most homeowners may find pH monitoring to be cumbersome. However, as a practice, the addition of lime before tilling the material into the soil may assist in reducing pathogens. Further work as applied to composting toilet residuals is needed in this area.)*

- *Vector Attraction Reduction - The residuals are promptly tilled into the soil or buried so that nothing remains exposed to the surface [WAC 173-308-080(4)(b)].*

- *Site Management and Access Restrictions – See "Area of Application" and "Pathogens" above.*

- *Annual Application Rate – The residual would have to be applied to an area of land at a recommended rate [WAC 173-308-080(6)]*

- *Recordkeeping - A clear record is kept of how much material was applied, when it was applied, and where it was applied [WAC 173-038-290(6)]*

- *Requirement to Obtain and Provide Information – Any person who prepares or applies biosolids to the land must obtain and provide information as required [WAC 173-308-120].*
  - *The land is owned or explicitly controlled by the person who applies it*

Other management options are also available under the Washington State Biosolids Management regulations, Chapter 173-308 WAC, which should be consulted for a complete understanding of the requirements associated with managing the product of composting toilets either as domestic septage or as biosolids.

In addition to the requirements noted above, composted material applied to the land must meet the horizontal separation requirements established for the disposal component in WAC 246-272-09501 [Table I – Minimum Horizontal Separation], and the vertical separation requirements established for gravity distribution systems in WAC 246-272-11501 [Table IV – Methods of Effluent Distribution for Soil Types and Depths]

***OTHER MANAGEMENT OPTIONS**:*

1. *Collection and management by a licensed domestic septage pumper/hauler [WAC 296-272-19501]*

2. *Disposal of the product as solid waste into the municipal solid waste stream (if allowed within the given jurisdiction) [WAC 173-08-060(3)], [WAC 173-351-220(10)]*

REFERENCES

1. Enferadi KM, Cooper RC, Goranson SC, Olivieri AW, Poorbaugh JH, Walker M, and Wilson BA. A Field Investigation of Biological Toilet Systems and Grey Water Treatment. State of California Department of Health Services, Berkeley, California. US Environmental Protection Agency, Wastewater Research Division, Municipal Environmental Research Laboratory, Cincinnati, Ohio. Grant Number R805942-01. EPA/600/2-86-069. 1980.

2. Del Porto and Steinfeld D and Steinfeld C. *The Composting Toilet System Book, A Practical Guide to Choosing, Planning and Maintaining Composting Toilet Systems, a Water-Saving, Pollution-Preventing Alternative*. The Center for Ecological Pollution Prevention, Concord, Massachusetts. 1999.

3. NSF International. Non-Liquid Saturated Treatment Systems, ANSI/NSF 41 – 1998. American National Standard/NSF International. Ann Arbor, Michigan. 1998.

4. Washington State Department of Health. List of Approved Systems and Products, As Established in Chapter 246-272 WAC, On-Site Sewage Systems. Olympia, Washington. October 1997 as updated, or the most recent revision.

5. Feachem RG, Bradely DJ, Garelick H and Mara DD. *Sanitation and Disease – Health Aspects of Excreta and Wastewater Management*. World Bank Studies in Water Supply and Sanitation 3. John Wiley & Sons, New York. 1983.

6. Esrey SA, Gough J, Rappaport D, Sawyer R, Simpson-Hebert M, Vargas J, and Winblad U. *Ecological Sanitation*. Swedish International Development Cooperation Agency (Sida), Stockholm. 1998.

Subsection A2 – Incinerating Toilets

Introduction — An incinerating toilet is a self-contained unit that reduces non-water-carried human sanitary wastes to ash and evaporate the liquid portion. Wastes are deposited directly into a combustion chamber and are incinerated upon a signal. The process is fueled by LP or natural gas, fuel oil or electricity.

1. **Incinerating Toilet Performance Standards**

1.1. **Listing —**Specific proprietary incinerating toilet systems are listed by the DOH on its *List of Approved Systems and Products*[1] when the manufacturer or designated manufacturer representative demonstrates that the product meets or exceeds the appropriate testing requirements.

1.2. **Testing —**

1.2.1. **Proprietary Products**

1.2.1.1. Proprietary products are those systems or components thereof that are held under patent, trademark, or copyright.

1.2.1.2. Proprietary products must be tested by a qualified party independent from the manufacturer.

1.2.1.3. Electrical incinerating toilets of proprietary design must be tested according to the specifications and protocols established in the National Sanitation Foundation (NSF) Standard No. 41 for Wastewater Recycle/Reuse and Water Conservation Devices [NSF 41 – November 1978, Revised May 1983][2].

1.2.1.4. Gas-fired incinerating toilets of proprietary design must be tested according to the specifications and protocols established both in the National Sanitation Foundation (NSF) Standard No. 41 for Wastewater Recycle/Reuse and Water Conservation Devices [NSF 41 – November 1978, Revised May 1983][2] and in the American National Standards Institute — Standard ANSI Z21.61-1983 (R 1996): Toilets, Gas-Fired[3].

1.2.1.5. To be listed on the *DOH List of Approved Products and Systems*[1], DOH does require that NSF standards be met, but does not require manufacturers to have testing and analysis of their product, or on-going product certification, by NSF.

Other testing facilities may be reviewed and approved by DOH, on a case-by-case basis.

1.2.2. **Public Domain Systems**

1.2.2.1. A public domain system is a system or design which is not protected by patent, trademark, or copyright, and is therefore available to be used by any member of the public without cost or obligation to a patent, trademark, or copyright holder.

1.2.2.2. The DOH is not aware of any public domain incinerating toilets at this time.

2. Incinerating Toilet Application Standards

2.1 **Permitting –** The local health officer or department shall only permit installation of alternative systems for which there are alternative system guidelines (referred to as "Recommended Standards and Guidance,") or a proprietary device if it appears on the DOH *List of Approved Systems and Products*[1].

2.1.1 **RS&G** - Recommended Standards and Guidance have been approved by the DOH for incinerating toilets.

2.1.2 **Listed Products** - For proprietary products, only the specific models listed by the DOH on its *List of Approved Systems and Products*[1] are approved. Others in manufacturers' product-lines are not approved for use in Washington State. If in doubt, check with DOH for current listing information.

2.1.3 **Permits Required** - Installation, and if required, operational, permits must be obtained from the appropriate local health officer prior to installation and use.

2.2 **Use Criteria —** Incinerating toilets may be used where occupancy or use patterns are full-time or part-time, permanent or temporary, commercial or residential.

2.2.1 Where potable water <u>is</u> provided and greywater <u>is</u> generated, incinerating toilets may only be used when combined with an approved on-site greywater treatment and disposal system, or public sewage system.

2.2.2 Where potable water <u>is not</u> provided and greywater <u>is not</u> generated, incinerating toilets may be used without an approved on-site greywater treatment and disposal system or public sewage system.

2.3 **Influent Characteristics —** Washington state currently approves incinerating toilets that do not use flush water to transport excrement and toilet paper from the toilet to the treatment chamber. Only urine, feces, and toilet paper are introduced into the incinerating toilet system.

2.4 **Incinerating Toilet Size / Model Selection —** For proprietary incinerating toilets, follow the number of users or uses per day identified on the *List of Approved Systems and Products*, DOH[1]. The DOH is not aware of any non-proprietary public domain incinerating toilets at this time.

2.5 **Installation —**

2.5.1 Incinerating toilets must be installed according to the manufacturer's instructions in compliance with state and local requirements.

2.5.2 Incinerating toilets must be installed by a person approved by the local health officer.

2.6 **Horizontal Separation —**

2.6.1 For incinerating toilets installed entirely within a structure or a service vault, there are no specific set-back requirements.

2.6.2 For incinerating toilets where a part of the unit is installed directly in or on the ground, on the exterior of or below the structure served, the setback requirements are the same as prescribed for septic tanks in WAC 246-272-09501.

2.7 **Vertical Separation —**

2.7.1 For incinerating toilets installed entirely within a structure or a service vault, there are no specific vertical separation requirements.

3. Incinerating Toilet Design Standards —

3.1. **Access Ports —** Access ports must be sized and located to facilitate the installation, removal, sampling, examination, maintenance, and servicing of components and compartments that require routine maintenance and inspection.

3.2. Incinerating Toilet Design Standards —

3.2.1. Materials

3.2.1.1. Materials used in the construction of incinerating toilets must be capable of resisting adverse conditions anticipated in the typical use environment, including climate, process temperatures, and cleaning procedures as prescribed by the manufacturer. All materials used must be durable and easily cleaned. Dissimilar materials may be used in mating parts, but must have galvanic compatibility or be joined with insulating fittings.

3.2.2. Safety

3.2.2.1. Components must be designed and constructed so as not to present any hazardous or unsafe condition which may adversely affect personnel or property.

3.2.2.2. All electrical work, materials, and equipment must comply with applicable provisions of the National Electrical Manufacturers' Association (NEMA), and the National Electrical Code, as well as local codes.

3.2.2.3. All gas-fired incinerating devices must comply with the applicable safety provisions of ANSI Standard Z21.61-1983 (R1996) for Gas-Fired Toilets.

3.2.3. Design Criteria

3.2.3.1. Incinerating toilets must be capable of accommodating full or part-time usage.

3.2.3.2. The devices must be watertight and designed to prevent the discharge of untreated wastes to the environment.

3.2.3.3. Ventilation components must be independent of other household venting systems. Venting connections must not be made to room vents or to chimneys. All vents must be designed to prevent flies and other insects from entering the device.

3.2.3.4. Component parts which are subject to malfunction, wear or require cleaning must be accessible for inspection, cleaning, repair or replacement. Surfaces which are accessible to the user must be easily cleaned.

4. **Incinerating Toilet Operation & Maintenance Standards —**

4.1. **General Standards —**

4.1.1. The owner / operator of the on-site sewage system must notify the local health department when the unit fails to function properly.

4.1.2. The residence or facility owner is responsible for assuring proper operation and providing timely maintenance of the incinerating toilet and all other components of the on-site sewage treatment and disposal system (greywater treatment and disposal component).

4.1.3. The authorized proprietary product representative must instruct, or assure that instruction is provided to, the residence or facility owner in proper operation of the incinerating toilet. Emphasis must be placed on those aspects related to operating and maintaining the incinerating toilet within its normal operating range.

4.2. **Owner's Manual —** Each incinerating toilet system must be accompanied by a comprehensive owner's manual developed / assembled by the system designer and/or installer that addresses all components of the entire on-site wastewater system. The manual may be a collection of individual system component manuals. The authorized proprietary product representative must provide a manufacturer-prepared manual to the sewage system designer for the system owner. The manual(s) must be written to be easily understood by the owner and must include, at a minimum:

4.2.1. The system's primary functional components, equipment manufacturer(s) and model designation;

4.2.2. A statement designating treatment capacity (such as number of users or uses per day).

4.2.3. A functional description of system operation, including diagrams illustrating basic system design and flow-path;

4.2.4. A clear statement of examples of the types of waste that can be effectively treated by the system;

4.2.5. A list of household substances that, if discharged to the system, may adversely affect the system, the process, or the environment;

4.2.6. Comprehensive operating instructions that clearly delineate proper function of the system, operating and maintenance responsibilities of the owner and authorized service personnel, and service-related obligations of the manufacturer(s);

4.2.7. Requirements and recommended procedures for the periodic removal of residuals from the system;

4.2.8. A course of action to be taken if the system is to be used intermittently or if extended periods of non-use are anticipated, or if subjected to an electrical power interruption;

4.2.9. Detailed methods and criteria to be used to identify system malfunction or problems;

4.2.10. List of replacement parts;

4.2.11. Specifications pertaining to the energy source and energy required for proper operation of the incinerating toilet; and

4.2.12. The name and telephone number of an appropriate service representative to be contacted in the event that a problem with the system occurs.

4.3. **Installation Manual —** incinerating toilet manufacturers must provide comprehensive and detailed installation instructions to authorized representatives. Manufacturers of other system components must make available to the sewage system designer and/or installer similar documentation. The manual must be written to be easily understood by the installer and must include, at a minimum:

4.3.1. A numbered list of system components and an accompanying illustration, photograph, or print in which the components are respectively identified;

4.3.2. Design, construction, and material specifications, for the system's components;

4.3.3. Wiring schematics for the system's electrical components;

4.3.4. Off-loading and unpacking instructions including safety considerations, identification of fragile components, and measures to be taken to avoid damage to the system;

4.3.5. A process overview of the function of each component and the expected function of the entire system when all components are properly assembled and connected;

4.3.6. A clear description of system installation requirements including plumbing and electrical power requirements, ventilation, air intake protection, bedding, hydrostatic displacement protection, water tightness, slope, and miscellaneous fittings and appurtenances;

4.3.7. A sequential installation procedure from the residence out;

4.3.8. Repair or replacement instructions in the event that a system has flaws that would inhibit proper functioning and a list of sources where replacement components can be obtained; and

4.3.9. A detailed start-up procedure.

4.4. **O&M Service Recordkeeping and Reporting —** The extent of the data reported and the frequency of reporting depends on various issues, such as the complexity of the overall on-site sewage system and the risk (to public health or the environment) presented by specific site characteristics. A greater monitoring or service frequency and an increase the detail of reporting may result. The local health officer must specify the type of information to be reported, to whom it needs to be reported, the format of the information and the frequency of reporting.

4.5. **System Operation and Maintenance —** Follow the manufacturers instructions for operation and maintenance.

4.6. **Disposition of the Final Product —** Removal, beneficial use or disposal of incinerated materials must be done in a manner that meets federal, state and local regulations.

REFERENCES

1. Washington State Department of Health. List of Approved Systems and Products, As Established in Chapter 246-272 WAC, On-Site Sewage Systems. Olympia, Washington. October 1997 as updated, or most recent revision.

2. National Sanitation Foundation. National Sanitation Foundation Standard No. 41 for Wastewater Recycle/Reuse and Water Conservation Devices, Ann Arbor, Michigan. November 1978, Revised May 1983.

3. American National Standards Institute — Standard ANSI Z21.61-1983 (R 1996): Toilets, Gas-Fired. Revised 1996.

Subsection A3 – Vault Toilets

Introduction — A vault toilet is an on-site sewage system that incorporates 1) a structure enclosing a toilet above a water-tight (preventing liquid infiltration into the soil) storage chamber for human waste, 2) the services of a sewage pumper/hauler, and 3) the off-site treatment and disposal for the sewage generated. Portable chemical toilets are not included in this category.

1. **Vault Toilet Performance Standards**

1.1. **Listing —**Specific vault toilets may be listed by the DOH on its *List of Approved Systems and Products*[1] when the manufacturer or designated manufacturer representative demonstrates that the product meets or exceeds the appropriate testing requirements.

1.2. **Testing —**

1.2.1 Proprietary and public domain vault toilets must be tested according to DOH standards for wastewater tanks.

1.2.2 Specifications, where provided in this document, have been identified as appropriate for vault toilet systems.

2. **Vault Toilet Application Standards**

2.1 **Permitting** – The local health officer or department shall only permit installation of alternative systems for which there are alternative system guidelines (referred to as "Recommended Standards and Guidance,") or a vault toilet if it appears on the DOH *List of Approved Systems and Products*[1].

2.1.1 **RS&G** - Recommended Standards and Guidance have been approved by the DOH for vault toilets.

2.1.2 **Listed Products** - Only the specific models listed by the DOH on its *List of Approved Systems and Products* are approved. Others in manufacturers' product-lines are not approved for use in Washington State. If in doubt, check with DOH for current listing information.

2.1.4 **Permits Required** - Installation, and if required, operational, permits must be obtained from the appropriate local health officer prior to installation and use.

2.2 **Use Criteria —** Vault toilets may be used where occupancy or use patterns are full-time or part-time, permanent or temporary, commercial or residential.

2.1.1. Where potable water is provided and greywater is generated. Vault toilets may only be used when combined with an approved on-site greywater treatment and disposal system, or public sewage system.

2.1.2. Where potable water is not provided and greywater is not generated. Vault toilets may be used without an approved on-site greywater treatment and disposal system or public sewage system.

2.2. **Influent Characteristics —** Washington State currently approves only vault toilets that do not use flush water to transport sewage from the toilet to the treatment / storage receptacle. Only urine, feces and toilet paper are introduced into the vault toilet units.

2.3. **Vault Toilet Size / Model Selection —** For vault toilets, follow the design standards.

2.4. **Installation —**

2.4.1. Vault toilets must be installed according to the manufacturer's instructions in compliance with state and local requirements.

2.4.2. Vault toilets must be installed by a person approved by the local health officer.

2.5. **Horizontal Separation —**

2.5.1. For vault toilets the setback requirements are the same as prescribed for septic tanks in WAC 246-272-09501.

2.5.2. Vault toilets must not be installed in areas subject to surface water flooding.

2.6. **Vertical Separation —**

2.6.1. For vault toilets there is no minimum vertical separation between the lowest portion of the vault and the highest seasonal water table or creviced bedrock.

2.7. **Suitable Soils —**

2.7.1. Installation of vault toilets is not dependent upon soil type, as the soil is not used to treat or dispose of vault contents.

3. **Vault Toilet Design Standards —**

3.1. **Access Ports —** Access ports must be sized and located to facilitate the installation, removal, sampling, examination, maintenance, and servicing of components and compartments that require routine maintenance and inspection. Manholes, risers or service vaults used for access ports must be protected against unauthorized access.

3.2. **Design Criteria —** (Note: the following information is excerpted from the In-Depth Design and Maintenance Manual for Vault Toilets, USDA, Forest Service (July 1991)[2]. This document was developed for the Forest Service, and as such is directed to the use of vault toilets in campground and other remote settings. The design concepts it presents are applicable to other applications of vault toilets.

The recommended standards excerpted below are for private, individual homeowner vault toilet use. When designing and reviewing designs for public settings (parks, campgrounds, rest areas, etc.) the reader is directed to follow the full design criteria in the design and maintenance manual. Referring to this design manual is highly recommended when designing, placing, constructing and maintaining a vault toilet for any application. Considerable more detail and explanation is presented in the complete manual.

3.2.1. **The Vault**

3.2.1.1. There must be one vault for each toilet riser.

3.2.1.2. All interior vault surfaces must be sealed to prevent leaking and absorption of odors into the material used to construct the vault. If the building floor slab is the top of the vault, then the underneath side of the floor slab (top interior of the vault) must be sealed to prevent odor absorption.

3.2.1.3. The vault must be adequate to withstand the anticipated structural, hydraulic, and buoyant forces. The vault must not become buoyant when in contact with groundwater. The vault surfaces must be resistant to corrosion and damage from additives and chemicals used in maintenance.

3.2.1.4. The vault must have a bottom slope of 1 inch per ft. from under the toilet riser towards the outside cleanout area so that the waste can be more thoroughly removed.

3.2.1.5. The vault must have a 24-inch diameter (minimum) lightweight manhole cover installed to the rear or side of the building, located over the lowest portion of the vault. The manhole cover must be sealed to prevent air and water from entering the vault. The manhole cover should be raised, with the surrounding concrete sloped away using a minimum slope of ½ Inch per ft. (Manhole covers are only for vault toilets.)

3.2.1.6. The size of the vault is determined by the amount of use at each site. The size is usually 750 to 1,000 gal. For estimating purposes, 1,500 uses equals approximately 100 gal.

3.2.1.7. The depth of the vault must be no deeper than 5 ft.

3.2.2. Building Interior Floor Surface

3.2.2.1. The floor must be sloped ½ inch per ft from the back to the front door so that water will not "pocket" and cleaning will be easier.

3.2.2.2. The floor must be completely sealed to prevent any staining or odor absorption.

3.2.3. Interior Building Walls and Ceiling

3.2.3.1. The walls must be nonporous.

3.2.3.2. The walls must be light in color to assist in reflecting available light.

3.2.3.3. The walls must be designed to be easily cleaned.

3.2.3.4. The walls must be free from ledges, angles, and shelves so that less dirt accumulates and cleaning is easier.

3.2.3.5. Each building must have an insulated ceiling so that the interior of the building is not heated by the sun shining on the roof.

3.2.4. Building

3.2.4.1. The weight of the building and sealed vault must exceed the buoyancy of the compartment to avoid floatation of buried vault privies where high ground water can occur.

3.2.4.2. The foundation or portion of the structure in contact with the soil must be rodent-proof to a depth of 18 inches and resistant to decay. Soil around the foundation must be sloped away from the building, compacted, and kept free of vegetation to discourage rodent burrowing.

3.2.4.3. Doors, must be self-closing, sturdy and designed to resist warping.

3.2.5. **Toilet Riser**

3.2.5.1. The riser must have no cracks and crevices on outside surfaces that can accumulate potentially odorous materials.

3.2.5.2. The riser must have a toilet seat and cover assembly that does not seal, preventing air from circulating through the chamber.

3.2.5.3. The riser must be easy to clean and impervious to oxidizing cleaning agents.

3.2.6. **Lighting**

3.2.6.1. Lighting within the building must be adequate for the visitor to comfortably function, but not directed in such a way that the visitor can see the waste In the vault. Do not use overhead skylights.

3.2.7. **Air Vent for the Building**

3.2.7.1. The vent in the building, necessary to supply replacement air for the air drawn from the vault, must be around 120 sq. inches of free area for a single unit toilet.

3.2.7.2. There must be <u>only one</u> vent opening in the building. The opening must be placed only on one side of the building (the side that the prevailing wind blows against). The "side" can be either side, or the front or back of the building.

3.2.7.3. The vent must be located "head-high" on the building if there is a constant prevailing wind hitting that side. For shifting winds, the vent must be placed as low to the ground as possible and on the side where the wind is most predominant during the use period. If there is an up-canyon wind in the morning and a down-canyon wind during the afternoon, then the vent must be placed on an adjacent wall surface as low to the ground as possible so the wind has the least effect of aspirating air from the building.

3.2.7.4. There must be no screen in the vent opening unless the size is l/4-inch mesh (least dimension).

3.2.8. Vent to Aspirate Odors Out of the Vault

3.2.8.1. The vault vent must be a minimum of 12 inches in diameter. Each vault must have its own vent. The 12-inch size is for single unit toilets only.

3.2.8.2. The top of the vent pipe must be a minimum height of 3 ft above the highest point of the roof.

3.2.8.3. The 12-inch diameter pipe above the roof must be painted a dark color to take advantage of potential convection resulting from the sun's energy as the sun heats the pipe. This effect is minimal, but everything helps.

3.2.8.4. The top of the 12-inch pipe must remain uncovered and unscreened. If a top is absolutely necessary, it should be a flat plate placed 12 inches above the top of the pipe and supported by three thin metal rods so as not to interfere with the aspiration aspects of the wind flowing over the open top pipe.

3.2.9. Placing the Building on the Site

3.2.9.1. A building that is correctly designed, in all aspects, will not function properly unless it is located properly in the field.

3.2.9.2. The building must be placed to take advantage of the wind flow or the sun's energy, preferably both.

3.2.9.3. The building must not be placed in a hollow, beneath an overhang, on the lee side of a ridge, immediately adjacent to a dense tree line, or in dense brush and/or trees. Both the building location and orientation are important.

3.2.9.4. Place the building so that odors emitted from the vent stack will not affect campground spurs, group use areas, boat launch areas, etc.

3.2.9.5. Do not place two single unit or two two-unit toilet buildings close together and in line with the direction of the prevailing wind.

4. Vault Toilet Operation & Maintenance Standards —

4.1. General Standards —

4.1.1. The owner / operator of the on-site sewage system must notify the local health department when the unit fails to function properly.

4.1.2. The residence or facility owner is responsible for assuring proper operation and providing timely maintenance of the vault toilet and all other components of the on-site sewage treatment and disposal system (greywater treatment and disposal component).

4.1.3. The authorized representative must instruct, or assure that instruction is provided to, the residence or facility owner in proper operation of the vault toilet. Emphasis must be placed on those aspects related to operating and maintaining the vault toilet within its normal operating range.

4.2. **Owner's Manual —** Each vault toilet system must be accompanied by a comprehensive owner's manual developed / assembled by the system designer and/or installer that addresses all components of the entire on-site wastewater system. The owner’s manual shall include specific instruction for system installation, operation and maintenance, and troubleshooting and repair. The manual may be a collection of individual system component manuals. For listed proprietary systems, the authorized proprietary product representative must provide a manufacturer-prepared manual to the sewage system designer for the system owner. The manual(s) must be written to be easily understood by the owner/operator and must include, at a minimum:

4.2.1. The system's primary functional components, equipment manufacturer(s) and model designation;

4.2.2. A statement designating treatment capacity (such as number of users or uses per day).

4.2.3. A functional description of system operation, including diagrams illustrating basic system design and flow-path;

4.2.4. A clear statement of examples of the types of waste that can be effectively treated by the system;

4.2.5. A list of household substances that, if discharged to the system, may adversely affect the system, the process, or the environment;

4.2.6. Comprehensive operating instructions that clearly delineate proper function of the system, operating and maintenance responsibilities of the owner and authorized service personnel, and service-related obligations of the manufacturer(s);

4.2.7. Requirements and recommended procedures for the periodic removal of residuals from the system;

4.2.8. A course of action to be taken if the system is to be used intermittently or if extended periods of non-use are anticipated, or if subjected to an electrical power interruption;

4.2.9. Detailed methods and criteria to be used to identify system malfunction or problems;

4.2.10. List of replacement parts;

4.2.11. Specifications pertaining to the energy source and energy required for proper operation of the vault toilet; and

4.2.12. The name and telephone number of an appropriate service representative to be contacted in the event that a problem with the system occurs.

4.3. **Installation Manual —** vault toilet manufacturers must provide comprehensive and detailed installation instructions to authorized representatives. Manufacturers of other system components must make available to the sewage system designer and/or installer similar documentation. The manual must be written to be easily understood by the installer and must include, at a minimum:

4.3.1. A numbered list of system components and an accompanying illustration, photograph, or print in which the components are respectively identified;

4.3.2. Design, construction, and material specifications, for the system's components;

4.3.3. Wiring schematics for the system's electrical components;

4.3.4. Off-loading and unpacking instructions including safety considerations, identification of fragile components, and measures to be taken to avoid damage to the system;

4.3.5. A process overview of the function of each component and the expected function of the entire system when all components are properly assembled and connected;

4.3.6. A clear description of system installation requirements including plumbing and electrical power requirements, ventilation, air intake protection, bedding, hydrostatic displacement protection, water tightness, slope, and miscellaneous fittings and appurtenances;

4.3.7. A sequential installation procedure from the residence out;

4.3.8. Repair or replacement instructions in the event that a system has flaws that would inhibit proper functioning and a list of sources where replacement components can be obtained; and

4.3.9. A detailed start-up procedure.

4.4. **O&M Service Recordkeeping and Reporting —** The extent of the data reported and the frequency of reporting depends on various issues, such as the complexity of the overall on-site sewage system and the risk (to public health or the environment) presented by specific site characteristics. A greater monitoring or service frequency and an increase the detail of reporting may result. The local health officer must specify the type of information to be reported, to whom it needs to be reported, the format of the information and the frequency of reporting.

4.5. **System Operation and Maintenance —**

4.5.1. Materials which are not rapidly biodegradable or larger than three inches in diameter should never be disposed of in a vault toilet. Toilet paper will not cause problems.

4.5.2. Concrete is severely attacked by a high pH (9+), because the alkali combines with the calcium hydroxide and expands, causing what looks like freeze / thaw spalling. Type 5 cement, having less tricalcium aluminate (cementing agent), is commonly used to reduce alkali attack. However, penetration continues, so LIME must <u>never</u> be added to a vault toilet.

4.5.3. Contents of vault toilets must be removed at a frequency that protects public health by preventing user-contact with the vault contents.

4.6 **Disposition of the Final Product** - Contents removed must be hauled to a sewage treatment facility for treatment and disposal in a manner that is consistent with federal, state, and local requirements, including the federal sludge standard, 40 CFR Part 503, and the Washington state biosolids standard, Chapter 173-308 WAC.

REFERENCES

1. Washington State Department of Health. List of Approved Systems and Products, As Established in Chapter 246-272 WAC, On-Site Sewage Systems. Olympia, Washington. October 1997 as updated.

2. USDA. Depth Design and Maintenance Manual for Vault Toilets. Forest Service. July 1991.

Subsection A4 – Pit Toilets

Introduction — A pit toilet is an on-site sewage disposal unit consisting of a structure overlying an excavation not exceeding five feet in depth in which human excrement (human feces and urine) is directly deposited for permanent placement in the ground. Pit toilets, due to site and soil considerations, have very limited application.

1. **Pit Toilet Performance Standards**

   1.1. **Listing —** The DOH is not aware of any proprietary pit toilets at this time, and therefore has not listed pit toilet systems on the DOH *List of Approved Systems and Products*[1].

   1.2. **Testing —**

   1.2.1. **Proprietary Products –** The DOH is not aware of any proprietary pit toilets.

   1.2.2. **Public Domain Systems**

   1.2.2.1. A public domain pit toilet system is a pit toilet system or design which is not protected by patent, trademark, or copyright, and is therefore available to be used by any member of the public without cost or obligation to a patent, trademark, or copyright holder.

   1.2.2.2. Specifications, where provided in this document, have been identified as appropriate for pit toilet systems. Testing is not required of public domain pit toilets when designed, constructed, operated and maintained according to the specifications where provided in this document.

2. **Pit Toilet Application Standards**

   2.1. **RS&G** - Recommended Standards and Guidance have been approved by the DOH for pit toilets.

   2.2. **Permitting —** Installation, and if required, operational permits must be obtained from the appropriate local health officer prior to installation and use.

   2.3. **Use Criteria —** Pit toilets may be used where occupancy or use patterns are full-time or part-time, permanent or temporary, commercial or residential.

2.3.1. Where potable water is provided and greywater is generated, pit toilets may only be used when combined with an approved on-site greywater treatment and disposal system, or public sewage system.

2.3.2. Where potable water is not provided and greywater is not generated, pit toilets may be used without an approved on-site greywater treatment and disposal system or public sewage system.

2.4. **Influent Characteristics —** Washington State currently approves only pit toilets that do not use flush water to transport sewage from the toilet to the treatment / storage receptacle. Only urine, feces and toilet paper are introduced into the pit toilet units.

2.5. **Pit Toilet Size / Model Selection —** For pit toilets, follow the design standards below.

2.6. **Installation —**

2.6.1. Pit toilets must be installed in compliance with state and local requirements.

2.6.2. Pit toilets must be installed by a person authorized by the local health officer.

2.7. **Horizontal Separation —**

2.7.1. For pit toilets the setback requirements are the same as prescribed for disposal components in WAC 246-272-09501.

2.7.2. Pit toilets must not be installed in areas subject to surface water flooding.

2.8. **Vertical Separation —**

2.8.1. For pit toilets, a minimum vertical separation of four feet must be maintained between the pit bottom and the highest seasonal water table, restrictive layer, creviced bedrock, or soil type 1A.

2.9. **Suitable Soils —**

2.9.1. Pit toilets are not to be installed in soils consisting of medium sands or coarser (Soil Types 1A, 1B, 2A, 2B). Pit toilets may be installed only in Soil Types 3 through 6.

3. **Pit Toilet Design Standards —**

3.1. **Design Criteria —**

3.1.1. The depth of the pit must not exceed five feet. This allows for material accumulation of three feet prior to abandonment with a minimum two feet of soil cover when backfilled.

3.1.2. The building must completely cover the excavation, firmly contacting the ground to prevent accidental human, animal, or vector access to the contents of the pit.

3.1.3. Design elements found in Section A, Sub-Section A3 of this document (Vault Toilets), other than those specific to the sealed vault, may be applied to the design of a pit toilet.

4. **Pit Toilet Operation & Maintenance Standards —**

4.1. **General Standards —**

4.1.1. The owner / operator of the pit toilet must notify the local health department when problems are noted.

4.1.2. The residence or facility owner is responsible for assuring proper operation and providing timely maintenance of the pit toilet and all other components of the on-site sewage treatment and disposal system (greywater treatment and disposal component).

4.1.3. The authorized representative must instruct, or assure that instruction is provided to the residence or facility owner in proper operation of the pit toilet. Emphasis must be placed on those aspects related to operating and maintaining the pit toilet within its normal operating range.

4.2. **Owner's Manual —**

4.2.1 Each on-site sewage system incorporating a pit toilet as a component of the overall system (e.g., systems where potable water is provided and greywater is generated, and pit toilets are used when combined with an approved on-site greywater treatment and disposal system, or public sewage system) must be accompanied by a comprehensive owner's manual developed / assembled by the on-site sewage system designer that includes specific instruction for the overall system installation, operation and maintenance, and troubleshooting and repair. The manual may be a collection of individual system component manuals. The authorized proprietary product representative must provide a manufacturer-prepared manual to the sewage system designer for the system owner. The manual(s) must be written to be easily understood by the owner and must include, at a minimum:

4.2.1. The system's primary functional components, equipment manufacturer(s) and model designation;

4.2.2. A statement designating treatment capacity (such as number of users or uses per day).

4.2.3. A functional description of system operation, including diagrams illustrating basic system design and flow-path;

4.2.4. A clear statement of examples of the types of waste that can be effectively treated by the system;

4.2.5. A list of household substances that, if discharged to the system, may adversely affect the system, the process, or the environment;

4.2.6. Comprehensive operating instructions that clearly delineate proper function of the system, operating and maintenance responsibilities of the owner and authorized service personnel, and service-related obligations of the manufacturer(s);

4.2.7. Requirements and recommended procedures for the removal of residuals from the system, if necessary;

4.2.8. A course of action to be taken if the system is to be used intermittently or if extended periods of non-use are anticipated, or if subjected to an electrical power interruption;

4.2.9. Detailed methods and criteria to be used to identify system malfunction or problems;

4.2.10. List of replacement parts;

4.2.11. The name and telephone number of an appropriate service representative to be contacted in the event that a problem with the system occurs.

4.2.2 Each on-site sewage system incorporating a pit toilet as the sole component of the overall system (e.g., a park campground) must be accompanied by an owner's manual developed / assembled by the authorized representative that includes specific information regarding the pit toilet installation, operation and maintenance, and troubleshooting and repair.

4.3. **O&M Service Recordkeeping and Reporting —** The extent of the data reported and the frequency of reporting depends on various issues, such as the complexity of the overall on-site sewage system and the risk (to public health or the environment) presented by specific site characteristics. A greater monitoring or service frequency and an increase the detail of reporting may result. The local health officer must specify the type of information to be reported, to whom it needs to be reported, the format of the information and the frequency of reporting.

4.4. **System Operation and Maintenance —**

4.4.1. Pit toilets shall receive routine servicing to insure sanitation.

4.4.2. Relocation of a privy to another pit on the same site must be done only after consulting the local health department.

4.4.3. Abandoned pits must be backfilled with at least two feet of soil to normal ground level and surface depressions eliminated.

4.4.4. If the contents of pit toilets are removed from the pit, they must be handled in such a way the meets federal, state and local regulations, including the federal sludge standard, 40 CFR Part 503, and the Washington state biosolids standard, Chapter 173-308 WAC.

REFERENCES

1. Washington State Department of Health. List of Approved Systems and Products, As Established in Chapter 246-272 WAC, On-Site Sewage Systems. Olympia, Washington. October 1997 as updated.

<u>Section B</u> — Greywater Systems —

Introduction —

Greywater systems are virtually the same as combined-wastewater on-site sewage systems. Gravity flow greywater systems consist of a septic tank and a subsurface drainfield. Pressurized greywater systems consist of a septic tank, a pump chamber or vault, and a subsurface drainfield. Other types of alternative systems, pre-treatment methods and drainfield design and materials options may also be incorporated in greywater systems.

The primary distinction between a greywater system and a combined wastewater system is the lower volume of wastewater. As a result the size of the septic tank and the subsurface drainfield is smaller compared to a system that treats and disposes of all the household wastewater (combined) through a septic tank and drainfield.

*(To help assure that future household fixture and/or plumbing changes do not overload the greywater treatment and disposal system, the household and system plumbing must be clearly identified **GREYWATER ONLY—NOT FOR COMBINED WASTEWATER** .)*

In addition to the water conserving nature of waterless toilets / greywater systems, the greywater system drainfield can be designed and located to reuse greywater for sub-surface irrigation. Drainfield designs (methods and materials) which place the distributed wastewater in close proximity to the root zone of turf grasses, plants, shrubs and trees may be used to enhance the reuse potential of greywater as it is treated in the soil, assuring public health protection. A relatively new piping method and material is presented in Section C as an option for the disposal / reuse of greywater. (Note: with experience gained from greywater system use of this technology, standards for applying the methods and material to combined wastewater will be developed.

When greywater systems are designed, installed, and operated & maintained to maximize their potential as a greywater re-use irrigation system, various items should be considered. Among these are plant water and nutrient needs and limits, salt tolerances, depth of root zones, etc. The development of a landscape plan is recommended. Information about these issues is presented in the Appendix.

1. Performance Standards —

1.1. Greywater treatment & disposal / reuse systems must provide treatment and disposal at least equal to that provided by conventional on-site systems.

2. **Application Standards —**

2.1. All permitting, installation and inspection requirements are the same as required in Chapter 246-272 WAC.

2.2. Greywater on-site sewage systems may be used with new residential construction and existing dwellings. Internal household plumbing may be modified (consistent with local plumbing code) to route any portion of the household greywater to the greywater on-site sewage system.

2.3. Greywater on-site sewage systems may be located anywhere conventional or alternative on-site sewage systems are allowed. Site conditions, vertical separation, pretreatment requirements, setbacks and other location requirements are the same as described in Chapter 246-272 WAC.

2.4. Greywater on-site sewage systems must provide permanent, year-round treatment and disposal of greywater unless this is already provided by an approved on-site system or connection to public sewer (see Section 3.4 “Seasonal .vs. Year-round Greywater Reuse).

2.5. Greywater on-site sewage systems must be installed with an approved waterless toilet or other means of sewage treatment for blackwater approved by the local health officer.

2.6. Greywater systems are intended to treat and dispose “residential strength” greywater. Greywater exceeding typical residential strength must receive pre-treatment to at least residential strength levels.

3. **Design Standards —**

Design requirements for greywater on-site sewage systems, unless otherwise noted here, are the same as the requirements for combined wastewater systems presented in Chapter WAC 246-272.

3.1. Minimum daily design flows and wastewater tank sizes for greywater systems serving single family residences are listed in Table 1.

3.2. For residential facilities other than single family residences daily design flow must be at least 60 GPD per bedroom with a minimum design flow of 150 GPD per dwelling unit. Septic tank volume must be a minimum of 1.5 times the daily peak design flow with a minimum capacity of 1000 gallons.

3.3. Enhancing Sub-Surface Irrigation Potential —

3.3.1. Greywater may be used for subsurface irrigation of trees (including fruit trees), shrubs, flowers, lawns and other ground covers but *must not* be used for watering of food crops or vegetable gardens, any type of surface or spray irrigation, to flush toilets/urinals or to wash walls, sidewalks or driveways.

3.3.2. The disposal component of a greywater treatment system may be designed to enhance the potential for sub-surface irrigation. The efficiency of greywater reuse via subsurface irrigation depends upon the proximity of the drainfield to the root-zone of plants, shrubs, trees or turf, and the method of distribution. This may be enhanced by:

3.3.2.1. Installing narrower-than-normal trenches shallow in the soil profile (state rules do not have a minimum trench width; minimum trench depth is six inches).

Gravel and pipe size may limit how narrow a "conventional" trench may be. It is recommended that at least 2 inches of gravel be provided between the sides of the distribution pipe and trench sidewalls. Smaller gravel size (no less than ¾ inch) is recommended for narrow trenches.

3.3.2.2. Using pressure distribution to reduce the height of the trench cross-section to enable shallow trench placement, and to assure even distribution.

3.3.2.3. Use subsurface drip system (SDS) technology for shallow system placement and equal distribution in close proximity to plant, shrub, turf and tree roots. (See Section C of this document.)

3.3.3. Some agronomic issues that should be considered with greywater reuse are the water needs and salt tolerance of plants to be irrigated (see Appendix for related information). In many cases the volume of greywater generated may not meet the water needs of the landscape plantings. If potable water is used to augment greywater for irrigation within the same distribution network, a method of backflow prevention approved by the local health officer is required.

3.4. **Seasonal vs. Year-Round Greywater Reuse —** In some geographical and climatic areas, the frost-protection needs of an SDS or a conventional drainfield trench system may be counter-productive to effective greywater reuse via subsurface irrigation (distribution piping may be too deep for plant root systems). In these areas local health officers may permit seasonal systems where year-round treatment and disposal is provided by an approved sewage system and seasonal subsurface irrigation with greywater is provided by a separate system with a shallow drainfield or SDS. Where seasonal systems are allowed various administrative and design issues must be addressed.

3.4.1. Both drainfields must meet state & local rule requirements, including soil application rates, to assure treatment and disposal at least equal to that provided by conventional gravity or pressure on-site sewage systems according to Chapter 246-272 WAC.

3.4.2. Municipal sewer systems may provide year-round sewage disposal in conjunction with seasonal greywater treatment and disposal systems designed to enhance greywater reuse via subsurface irrigation.

3.4.3. Seasonal greywater treatment and disposal / reuse systems must include a three way diverter valve to easily divert greywater to the year-round disposal field or sewer when needed (when freezing is a problem).

3.5. Special Case / Laundry Wastewater —

3.5.1. Local health officers may permit “laundry wastewater only” greywater disposal or reuse systems for single family residences for either year-round or seasonal use. Greywater systems limited only to laundry wastewater (including laundry sinks) may differ from other greywater systems presented in this document according to the following:

3.5.1.1. A single compartment retention / pump tank, with a minimum liquid capacity of 40 gallons may be used in lieu of the tank recommendations in Table 1. The tank must be warranted by the manufacturer for use with wastewater and meet requirements listed in Appendix G of the 1997 edition of the Uniform Plumbing Code (UPC).

3.5.1.2. Minimum design flow for “laundry wastewater only” systems (for the purpose of drainfield sizing) must be based on the number of bedrooms in the residence and must be no less than 30% of the minimum greywater system design flows listed in Table 1. (see Appendix).

3.5.1.3. A wastewater filter or screen (with a maximum size opening of 1/16 inch) must be provided in an accessible location conducive to routine maintenance.

4. Operation and Maintenance Standards —

4.1 Homeowners are responsible for proper operation and maintenance of their greywater systems.

4.2. Operation and maintenance (O&M) requirements for greywater systems are similar to the O&M requirements of other comparable (combined wastewater) on-site sewage systems. Specific requirements will vary according to the county where the system is located and the specific type of system. See your local health jurisdiction for local system O&M requirements.

4.3. Operation and maintenance requirements of subsurface drip systems are unique and are outlined separately in Section C.

4.4. Effluent filters must be cleaned with a minimum frequency in accordance with manufacturer's recommendations.

Section C — Subsurface Drip Systems —

Introduction

A subsurface drip system (SDS) is an efficient wastewater distribution mechanism and may be used to enhance the subsurface irrigation potential of a greywater treatment and disposal / reuse system.

A SDS utilizes flexible, small diameter tubing (dripline) with in-line emitters to deliver effluent to the soil under pressure at slow, controlled rates. Two common types of emitters are currently available: "turbulent flow" and "pressure compensating". Turbulent flow emitter flow rate increases with increasing pressure while pressure compensating emitters deliver a constant flow rate over a range of pressures.

No gravel is placed around, nor is geotextile placed over, the dripline. Peak flow capacity exist only within the pump chamber as the piping diameter accommodates insignificant storage. Driplines can be installed in a grid pattern on one foot centers (for sites with less than 20% slope) as well as in irregular patterns to accommodate contours on sloped sites, difficult site conditions, or landscape irrigation applications. Emitters can be specified that are spaced one foot apart along the dripline tubing. Filters prevent clogging of the emitters. Systems are commonly installed in a closed-circuit network with both distribution and flush manifolds to assure even distribution and for flushing lines and backwashing filters (see Figure 1).

Some common subsurface drip system components and their function are:

> **Driplines (or emitter lines)** — Small diameter, flexible, polyethylene tubing with "in-line" emitters.
>
> **Pressure Regulator** — Maintains constant pressure in drip lines (required for turbulent flow type emitters).
>
> **Pressure Regulator Bypass** — Enables pressure increases for flushing and cleaning emitters.
>
> **Vacuum Breakers (air vacuum relief valves)** — Prevents dirt from being sucked into driplines through emitters due to back siphoning or back pressure.
>
> **Control Valves** — Controls effluent flow throughout the system, for manual or automatic backwashing, to drain driplines or provide fresh water recharge to the system.
>
> **Control System —** Regulates normal flow and initiates system flush/back-flush cycles. The control system can consist of manual or automatic valves, switches, timers, or

automatic controllers such as *sequence controllers* or *programmable logic controllers* (PLCs). PLC controllers can be connected to a PC via a telemetry system.

Telemetry System — Transmits system performance information measured by sensors to a remote location by means of wires or electromagnetic waves.

Flow Meter — Monitors flow in the system.

Pressure Sensors — Monitors pressure differential across the filter.

Chemical Injector — Periodically injects chlorine or mild acids or alkalis into the system to remove bacterial slime or scale.

Distribution Manifold — Delivers wastewater from the control valve to the emitter lines.

Flush Manifold — Helps equalize pressure in the drip lines and for periodic system flushing (cleaning).

1. Performance Standards —

1.1. Subsurface drip systems (SDS) must be designed and installed to provide treatment and disposal at least equal to that provided by conventional pressure on-site sewage systems according to Washington State on-site sewage system rules (Chapter 246-272 WAC).

1.2. SDS must be warranted by the manufacturer for use with greywater and resistant to clogging from solids accumulation, slime build-up and root intrusion.

2. Application Standards —

2.1. Subsurface drip systems (SDS) are an approved alternative on-site sewage system for the disposal / dispersal of greywater as part of a greywater on-site sewage system in the state of Washington. (Note: Extending the use of SDS to combined wastewater is under consideration by the Washington State Department of Health (DOH).)

2.2. For SDS all permitting, installation and inspection, site conditions, vertical separation, pretreatment requirements, setbacks and other location requirements are the same as described in Chapter 246-272 WAC for conventional pressure distribution systems.

2.3. Subsurface drip systems (SDS) must be installed by qualified on-site sewage system installers with specific training in the installation of a SDS. Manufacturers' installation instructions and recommendations vary from one manufacturer to another. Installation knowledge and skill may be product-specific.

3. Design Standards —

Unless otherwise noted below, design standards for septic tanks, dosing chambers, pump chambers, and all electrical components and controls are the same as outlined in the Department's Guidelines for the Use of Pressure Distribution Systems, July 1996 (being revised summer / 1998).

3.1. Subsurface drip systems (SDS) must be designed by qualified on-site sewage system designers or engineers with specific training in the design and operational concepts of SDS. Manufacturers' recommendations and design criteria vary from one manufacturer to another. Design knowledge and skill may be product-specific.

3.2. Design of subsurface drip systems must be consistent with the manufacturer's recommendations and comply with state and local rules.

3.3. **Pre-treatment —**

3.3.1. The site and soil conditions may determine the degree of pre-treatment necessary.

3.3.2. Different SDS products may require different levels of pre-treatment. Follow the manufacturers' recommendations in conjunction with the site-induced pre-treatment requirements.

3.3.3. Different levels of pre-treatment may be obtained by the use of a septic tank, an aerobic treatment unit, or a sand filter following a septic tank.

3.4. **Drainfield Size —**

3.4.1. Soil loading rates for subsurface drip systems used as the distribution component of a greywater on-site sewage system must be in accordance with manufacturer's recommendations but are not to exceed state maximum loading rates based on soil type (see Table V in Chapter 246-272 WAC).

3.4.2. Emitter Spacing — A maximum of 1 square foot of drainfield absorption area for each emitter may be allowed (1 emitter per 1 sq. ft. of absorption area). So the minimum number of emitters required in a drip system is exactly equal to the minimum absorption area required (based on minimum design flow and maximum allowable application rate by soil type). This spacing requirement applies to primary treated greywater (septic tank effluent). A two foot emitter and dripline spacing may be allowed where greywater is pretreated to Treatment Standard 2 or better.

3.4.3. (NOTE: Designers of drip systems should be aware of the relationship between the minimum number of emitters required in a system, the rated emitter discharge (usually ½ or 1.0 gallon per hour), the maximum allowable loading rate of the soil type and the frequency and duration of doses applied to the system. The designer must ensure that the drainfield is never loaded at a greater rate than the maximum allowable loading rate based on soil type. This may require adjusting the frequency and volume of doses applied in a day - see SDS design example in Appendix).

3.5. **Dosing —**

3.5.1. Timed dosing is required for all subsurface drip systems. The minimum number of equally sized and spaced doses per day must be 6.

3.5.2. Means must be provided to monitor flow.

3.6. **Layout —**

3.6.1. Minimum dripline spacing must be 1 foot on level sites or sites with slopes up to 20% and 2 feet on sites with slopes between 20% and 45%.

3.6.2. Driplines may be installed in any pattern provided minimum absorption area, minimum number of emitters and minimum dripline spacing requirements are met.

3.6.3. When installed on sloping sites, driplines must be installed parallel with topographical contours.

3.6.4. When turbulent flow emitters are used on sloping sites, elevation differences between any two drip lines connected to the same valve must not exceed 6 feet.

3.6.5. Maximum dripline length must not exceed manufacturer's recommendations (based on the criteria that flow variation must not exceed 10% across the entire distribution system).

3.6.6. Driplines must be joined to the distribution and flush manifolds with compression fittings.

3.6.7. SDS must distribute greywater effluent evenly (flow variation must not exceed 10% between any two emitters in the entire distribution network).

3.6.8. Driplines must be installed at a minimum depth of 6 inches in original, undisturbed soil.

3.7. **Flushing —**

3.7.1. All subsurface drip systems must include both a distribution and a flush manifold for each absorption zone. Means must be provided to periodically flush lines and back-flush filters either with manual or automatic control valves.

3.7.2. All subsurface drip systems must include at least one port to connect a chemical injector when/if needed to inject chemicals such as chlorine to reduce slime build-up or mild acid to reduce scaling within driplines.

3.7.3. The return line from the flush process must be routed back to the septic tank or primary treatment unit in a manner that minimizes agitation of sediment within the tank (such as a plumbing flush line to a screened inlet tee).

3.7.4. Backwashing / flushing may be done continuously with a return to the septic tank or periodically based on a pre-set interval, the number of dosing cycles or the measurement of pressure difference across the filter (such as a 20% difference in pressure) or any combination of these criteria.

3.8. **Special Marking —**

3.8.1. Because SDS piping has historically been associated with irrigation applications there is an increased potential for direct human contact with the piping, emitters, and effluent. Therefore, SDS driplines, piping and fittings used must be clearly marked in a manner acceptable to the local health officer to identify the (non-potable) water source. Examples of acceptable markings are:

3.8.1.1. Color coding (purple) piping and fittings; and

3.8.1.2. Wrapping piping with an identifying tape with the words "Reclaimed Water - Do Not Drink" or equivalent

3.9. **Frost Protection —**Subsurface drip systems must be protected against frost damage (where necessary), including such measures as:

3.9.1. Installing the transport line and manifolds below the frost line,

3.9.2. Placing drain valves or weep holes at all low points with a gravel filled sump for drainage, and

3.9.3. Covering distribution lines with material that is resistant to freezing such as polyethylene tubing or chamber systems.

3.10. **Pressure Regulators —**

3.10.1. A pressure regulator is required for all subsurface drip systems *utilizing turbulent flow emitte*rs and for systems utilizing pressure compensating emitters where pressure can exceed 45 psi.

3.10.2. A pressure regulator bypass is required on all subsurface drip systems *utilizing turbulent flow emitters* so the operator can increase system pressure for flushing and clearing blockages in the emitters when needed.

3.11. **Vacuum Breakers (Air Vacuum Relief Valves)—**

3.11.1. At least one vacuum release valve per absorption zone, and at all high points in the distribution system must be installed to prevent soil particles from being drawn back into emitters during pressure changes in the system. All vacuum release valves and control valves must be installed at sufficient elevations to prevent drainage back into the valves when system pressure is turned off.

3.11.2. All vacuum release and control valves must be enclosed in covered access with a gravel sump (see Figure 2 in Appendix for example).

3.12. **Filters —**

3.12.1. All drip irrigation systems must include at least one filter: a minimum of 140 mesh (115 micron) rated at a flow of at least 25 gallons per minute. Other filters may be installed with manufacturer's recommendation and the approval of the local health officer.

3.12.2. Filters must be backwashed and the distribution system must be flushed as needed. The backwash and flush can be controlled either manually or automatically with a controller. If backflushing is to be accomplished manually a schedule for this procedure must be included in the operation and maintenance manual (see operation and maintenance standards). The filter must be accessible for cleaning and maintenance. The backwash must be returned to the septic tank or primary treatment unit.

4. Operation and Maintenance Standards —

4.1. Homeowners are responsible for proper operation and maintenance of their systems.

4.2. Operation and maintenance of subsurface drip systems must be in accordance with local health jurisdiction requirements. For areas where no such requirements exist, operation and maintenance must be in accordance with the manufacturer's recommendations, for both type and frequency of service.

4.3. All subsurface drip systems must be inspected by the installer or manufacturer's authorized representative within 30 days of initial use to assure proper system start-up.

4.4. The frequency of SDS routine O&M activities will vary depending on the level of pre-treatment provided. Higher levels of pre-treatment may lower the frequency of inspections and filter servicing. Higher levels of pre-treatment may, however, increase the overall frequency of O&M activity for the entire system, due to the complexity of the pre-treatment component.

Water Conserving On-Site Wastewater Treatment Systems

Appendices

Appendix A

Definitions

Accessible — When applied to a fixture, connection, appliance or equipment, means having access thereto, but which first may require the removal of an access panel, door, or similar obstruction **s**. *Readily accessible* means direct access without the necessity of removing any panel, door, or similar obstruction.

Alkalinity — Refers to the relative amounts of alkaline chemicals in a solution. Sodium, potassium, and calcium are alkaline chemicals and are often combined with carbonates, sulfates, or chlorides. Plants do not tolerate high concentrations of alkaline salts.

Agronomic Rates — Greywater application rates (to irrigated plants) which are based on the water needs of the plants to be irrigated rather than the maximum allowable loading rates (based on soil type) referenced in Chapter WAC 246-272.

Alternative On-Site Sewage System — An on-site sewage system other than a conventional gravity or conventional pressure distribution system for which the Department of Health has developed standards and guidance. Once the Department has developed standards and guidance for an on-site system it can be permitted by local health officers. Examples of approved alternative systems include sand filters, mounds, and aerobic treatment units.

Backwater Valve — A type of check valve installed in a drainage system to prevent reverse flow.

Biodegradability — The word biodegradable means that a complex chemical is broken down into simpler components through biological action. Do not be confused by the word biodegradable, which often is used to imply environmentally safe. Harmful chemicals as well as beneficial ones may be biodegradable.

Blackwater — Water that is flushed from toilets and urinals that contains human waste.

BOD_5 — The 5-day biochemical oxygen demand test (BOD_5) is a test which measures the molecular oxygen used by microorganisms during a five day incubation period at a temperature of 20^0C (68^0F) for the biochemical degradation of organic material (CARBONACEOUS DEMAND), and the oxygen used by microorganisms to oxidize inorganic material such as sulfides and ferrous iron. It also may measure the amount of oxygen used to oxidize reduced forms of nitrogen such as ammonia and organic nitrogen (NITROGENOUS DEMAND) if the microorganisms capable of mediating the reaction are present in the sample.

Boron — Considered a plant micronutrient, boron is required in only very, very small amounts. Most soils provide adequate amounts of this chemical. Concentrations only slightly higher than those considered beneficial can cause severe injury or death to plants.

Composting Toilet — A system designed to store and compost (primarily by unsaturated, aerobic microbial digestion) human excrement (human urine and feces) to a stable soil-like material called “humus.” These systems are commonly designed to accommodate fecal and urinary wastes (human excrement), toilet paper and small amounts of organic carbonaceous material added to assist their function.

Canopy — The uppermost branching and foliage of a tree or shrub.

Conductivity — A simple measure of the amount of dissolved chemicals in a solution. These chemicals can be beneficial or harmful. The higher the conductivity, the more dissolved salts and minerals are present. In general, the higher the concentration of dissolved salts and minerals in the water, the greater the potential for adverse affects on the environment and plant health.

Conventional On-site Sewage System — An on-site system consisting of a septic tank and a subsurface soil absorption system with either gravity or simple pressurized distribution of effluent.

Department — The Washington State Department of Health

Drip Irrigation — A system of crop irrigation involving the controlled delivery of water (usually at low application rates) to plants through a network of small diameter flexible poly tubing with small diameter openings called emitters.

Evapotranspiration — The loss of moisture from the soil due to a combination of the processes of evaporation and transpiration from the plants growing in the soil. Evapotranspiration varies with soil type and landscape position, local climate and plant types.

Greywater — Wastewater having the consistency and strength of residential domestic type wastewater. Greywater includes wastewater from sinks, showers and laundry fixtures but does not include toilet or urinal waters.

Incinerating Toilet — A self-contained unit that reduces non-water-carried human excrement (human urine and feces) to ash and evaporate the liquid portion. Wastes are deposited directly into a combustion chamber and are incinerated upon a signal. The process is fueled by LP or natural gas, fuel oil or electricity.

Local Health Officer —The health officer of the city, county, or city-county health department or district within the state of Washington, or a representative, authorized by and under the direct supervision of the local health officer, as defined in chapter 70.05 RCW.

Mesh —A parameter used to describe the size of screen openings or the size of particles that can be passed through a screen, usually in terms of the number of openings occurring per linear inch.

O&G (Oils and Greases) — Very stable organic compounds typically found in domestic sewage, not easily decomposed by bacteria. Most greases and oils are compounds of alcohol or glycerol with fatty acids. Oils are liquid at room temperature and greases are solids at room temperature.

Phosphate — A plant nutrient often added to soil as a fertilizer. Soils in some areas are low in phosphate and thus, there may be some benefit to plants if phosphate is present in greywater. This should not be relied upon, however, since many forms of phosphate are not readily usable by plants and soils.

Pit Toilet — An on-site sewage disposal unit consisting of a structure overlying an excavation not exceeding five feet in depth in which human excrement (human feces and urine) is directly deposited for permanent placement in the ground. Pit toilets, due to site and soil considerations, have very limited application.

Potable Water — Clean water which is satisfactory for drinking, culinary and domestic purposes and meets the drinking water standards established by the Washington Department of Health.

Pressure Compensating Emitters — Drip emitters that allow a constant discharge over a wide range of applied pressures.

Readily Accessible — Having direct access to a plumbing fixture, connection, appliance or equipment without the necessity of removing any panel, door, or similar obstruction.

Residential Strength Greywater — Greywater having the consistency and strength typically found in residential applications: acceptable characteristics of raw greywater are: $BOD_5 \leq 200$ mg/L, TSS $\leq$ 125 mg/L, O&G $\leq$ 25 mg/L .

Sodium — Can act as a plant poison by reducing the plant's ability to take up water from the soil. Too much sodium can destroy the structure of clay soils, making them slick and greasy by removing air spaces and thus preventing good drainage. Once a clay soil is damaged by sodium, it can be very difficult to restore it to a viable condition.

Subsurface Drip System (SDS) — A subsurface pressurized distribution system specifically designed to distribute effluent. Subsurface drip is ideal for reuse applications such as landscape irrigation but can also be a simple wastewater treatment and disposal mechanism.

TSS (Total Suspended Solids) — All solids (a mixture of fine, non-settling particles) that are physically suspended in wastewater.

Turbulent Flow Emitters — Drip emitters that allow a varying discharge depending on the pressure applied.

UPC — Uniform Plumbing Code (latest edition - 1997)

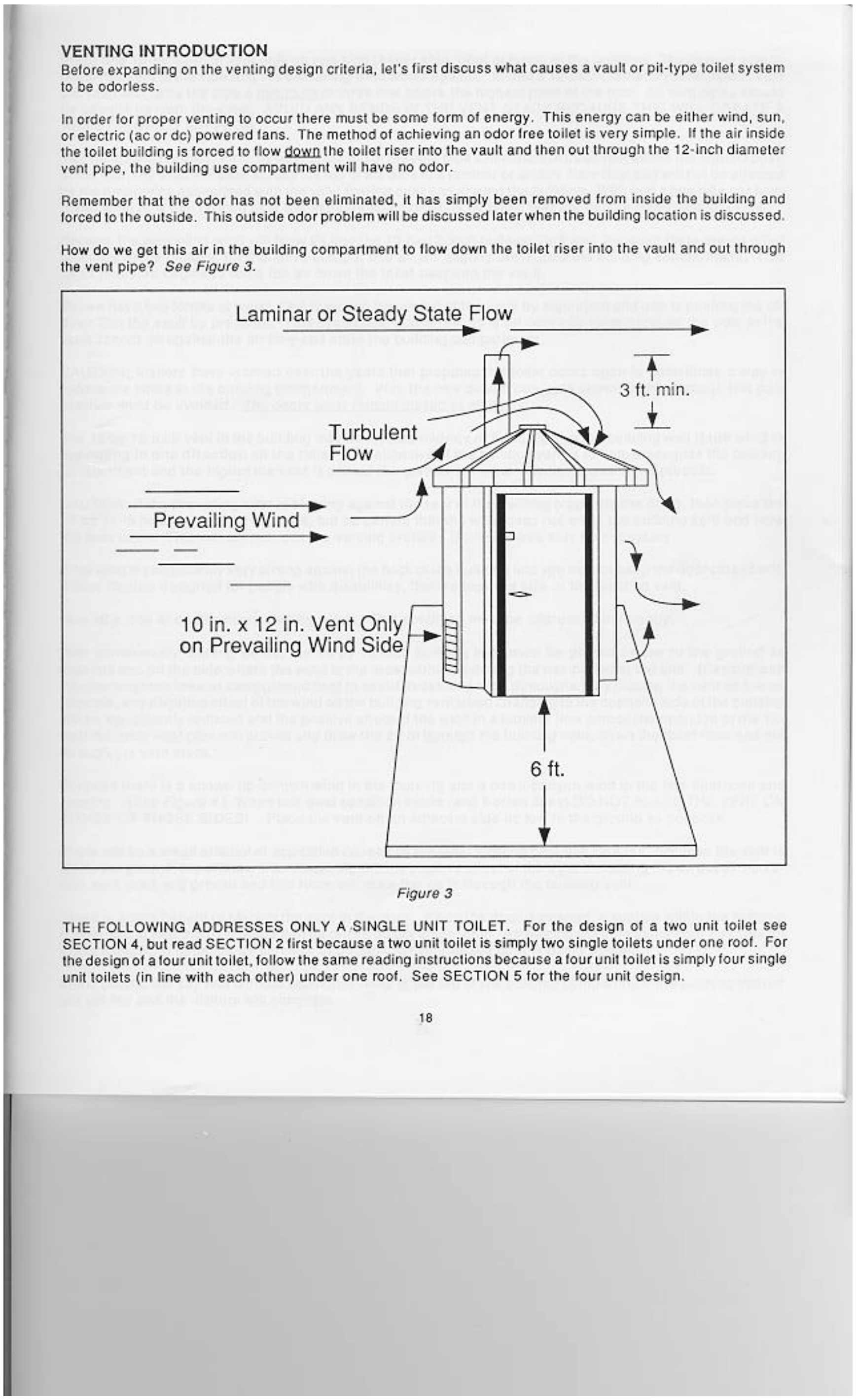
Vent System — A pipe or pipes installed to provide a flow of air to or from a drainage system or to provide a circulation of air within such system to protect trap seals from siphonage and back-pressure.

Vault Toilet — An on-site sewage system that incorporates 1) a structure enclosing a toilet above a water-tight (preventing liquid infiltration into the soil) storage chamber for human waste, 2) the services of a sewage pumper/hauler, and 3) the off-site treatment and disposal for the sewage generated. Portable chemical toilets are not included in this category.

Waterless Toilet — A non-discharging toilet; a device which uses no water for waste-transport but stores or reduces toilet and urinal wastes to either compost, ash, or an accumulation of wastes for removal, transport, and final disposal at an approved site.

Appendix B

Figures



VENTING INTRODUCTION

Before expanding on the venting design criteria, let's first discuss what causes a vault or pit-type toilet system to be odorless.

In order for proper venting to occur there must be some form of energy. This energy can be either wind, sun, or electric (ac or dc) powered fans. The method of achieving an odor free toilet is very simple. If the air inside the toilet building is forced to flow down the toilet riser into the vault and then out through the 12-inch diameter vent pipe, the building use compartment will have no odor.

Remember that the odor has not been eliminated, it has simply been removed from inside the building and forced to the outside. This outside odor problem will be discussed later when the building location is discussed.

How do we get this air in the building compartment to flow down the toilet riser into the vault and out through the vent pipe? *See Figure 3.*

Figure 3

THE FOLLOWING ADDRESSES ONLY A SINGLE UNIT TOILET. For the design of a two unit toilet see SECTION 4, but read SECTION 2 first because a two unit toilet is simply two single toilets under one roof. For the design of a four unit toilet, follow the same reading instructions because a four unit toilet is simply four single unit toilets (in line with each other) under one roof. See SECTION 5 for the four unit design.

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Figure 1 Vault Toilet

Generally, at night, the wind becomes still and dampness sets in. The stinky air from the vault, being forced out by the fan, can in some cases result in the entire recreation area being obnoxious in odors.If photovoltaics are used to drive a fan in a day use area, no timer is needed because when the sun goes down the fan will stop.

USING THE SUN FOR ENERGY (WITHOUT A FAN)

By placing the 12-inch diameter vent pipe in an enclosed and sealed metal shroud and facing the shroud in the south direction, the sun will heat the air between the shroud and the pipe evenly, all around the pipe. The pipe will then get considerably hotter than the outside ambient temperature and create a convection process that will draw the air out of the vault. (*See Figure 5.*)

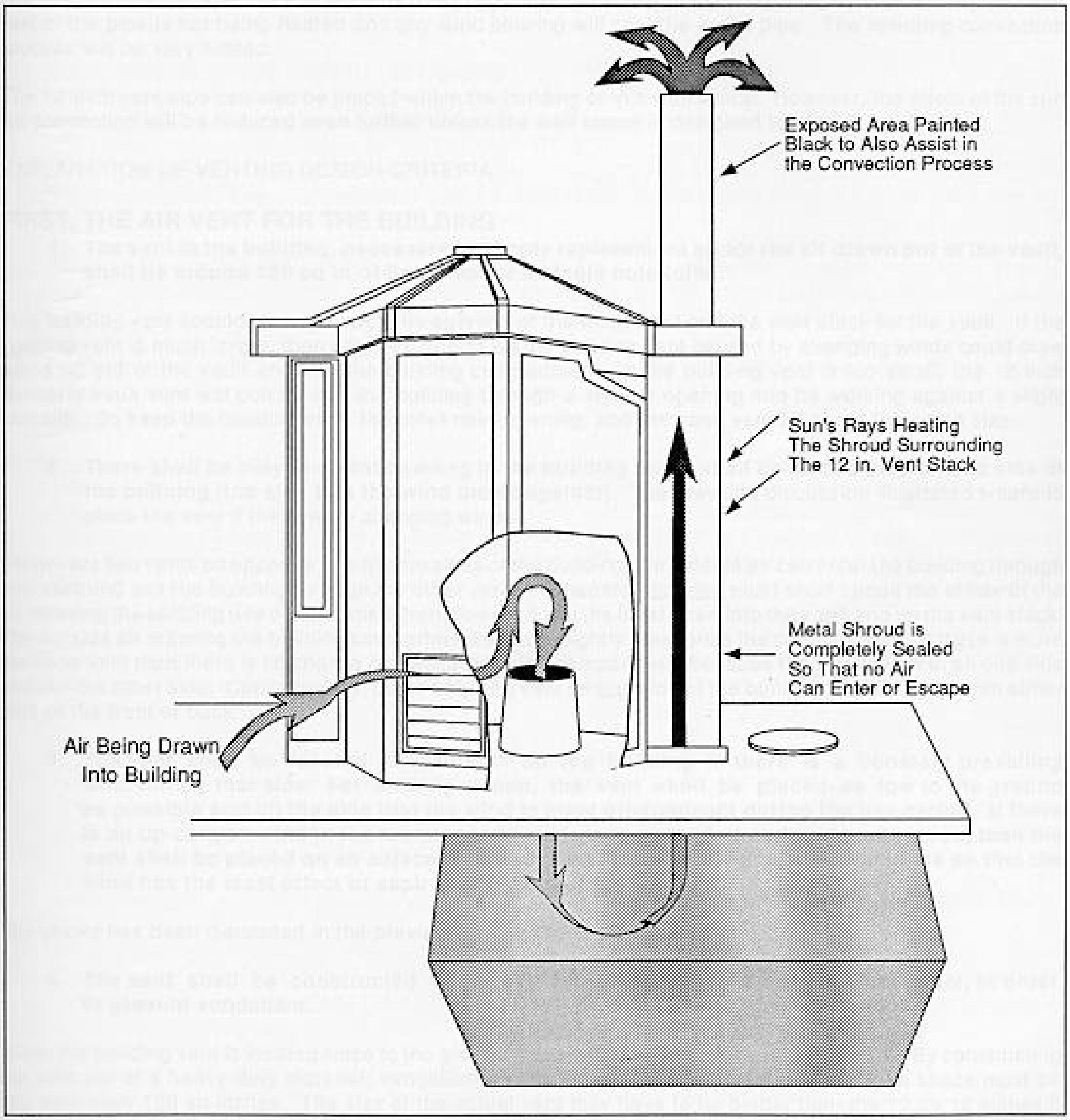

Fig. 2 Vault Toilet with Passive Ventalation

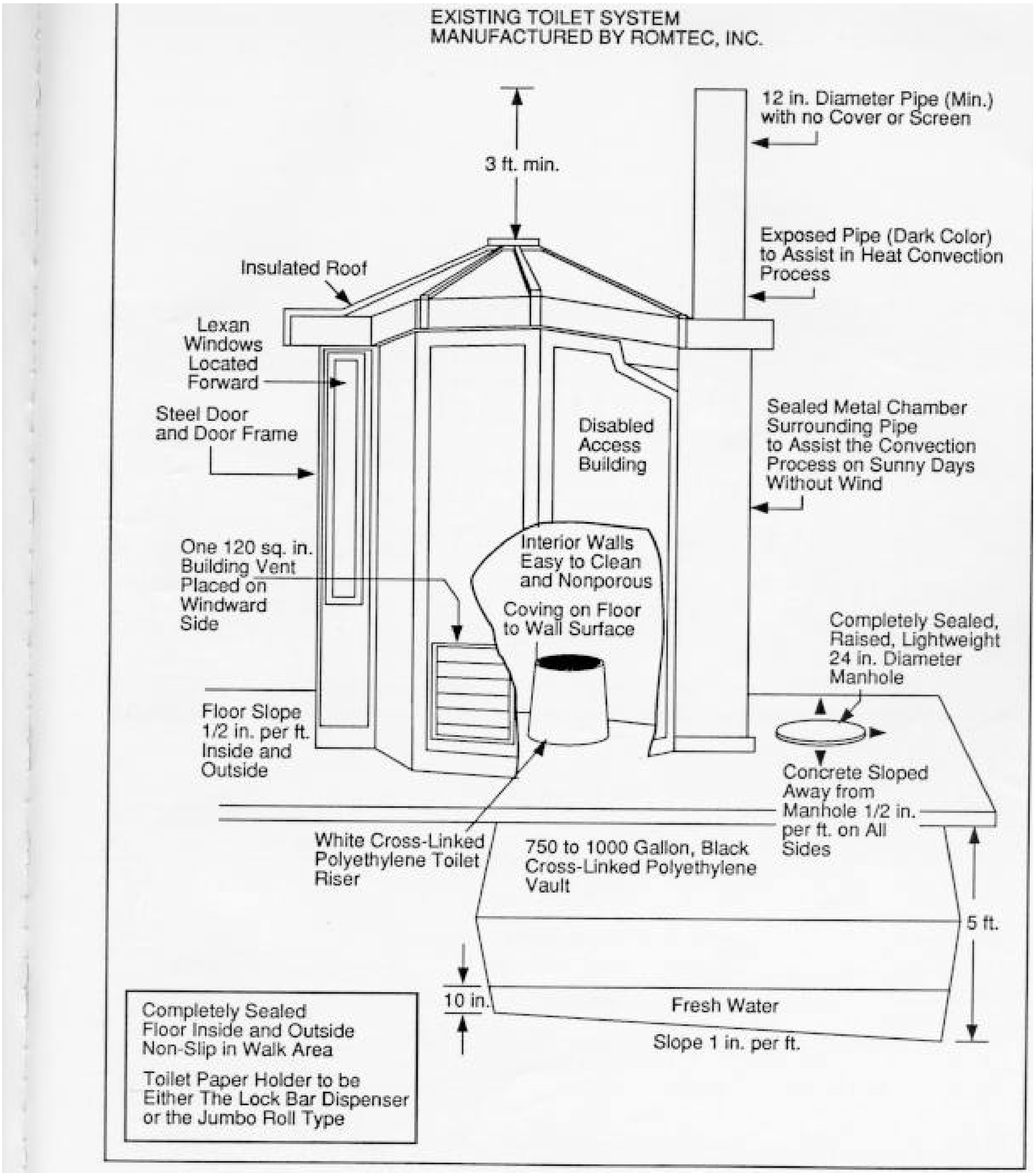

Figure 3 Vault Toilet

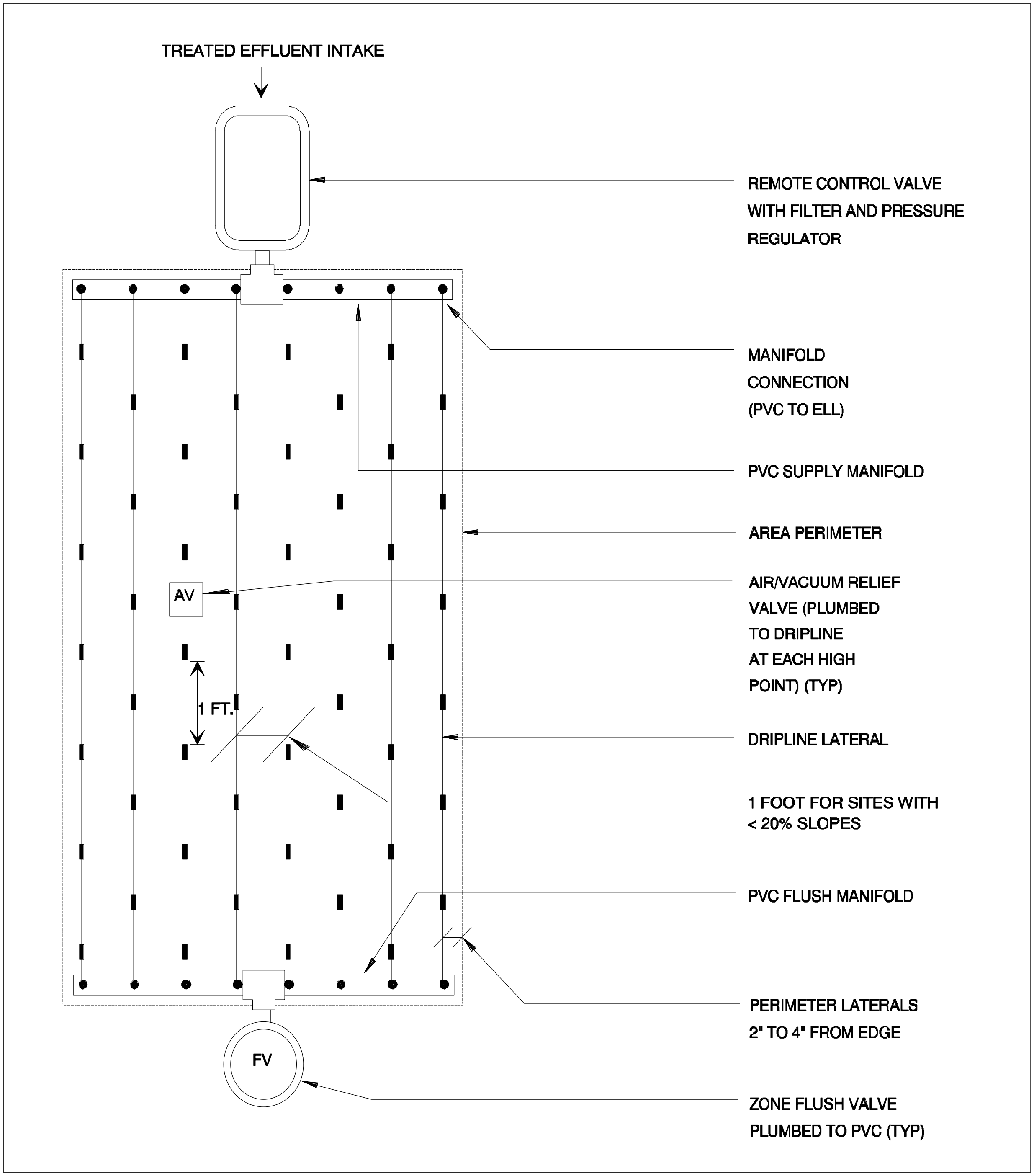

Fig. 4 Typical Subsurface Drip System Installation Detail

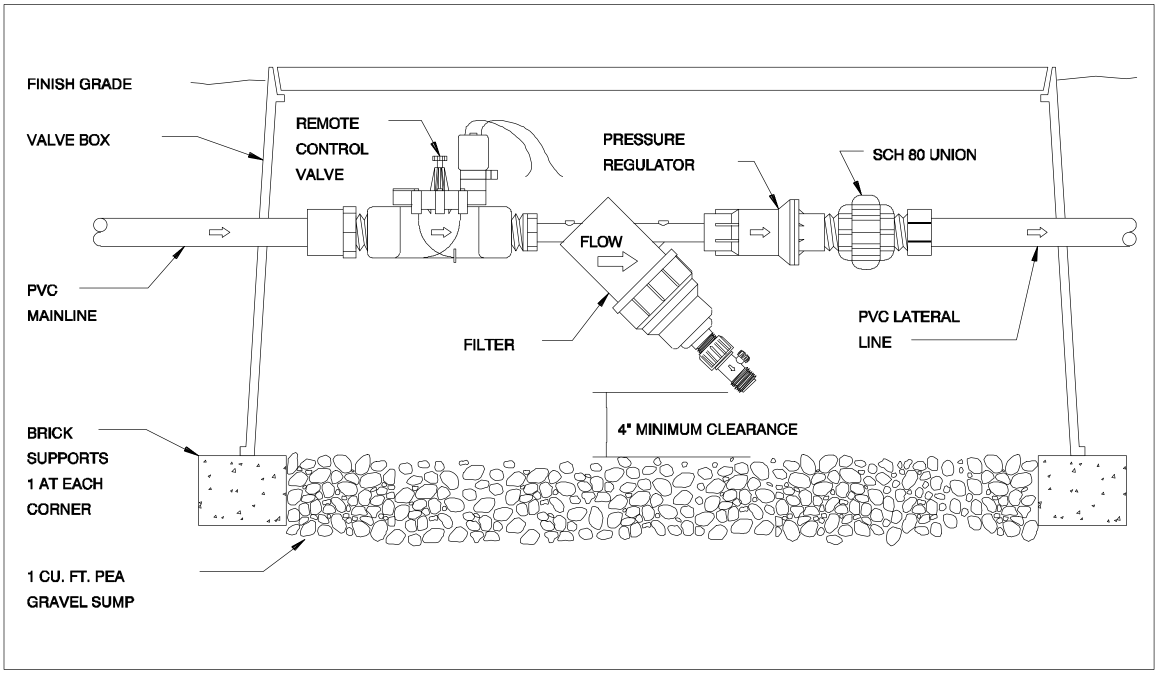

Fig 5 Control Valve, Filter and Pressure Regulator in Valve Box with Gravel Sump

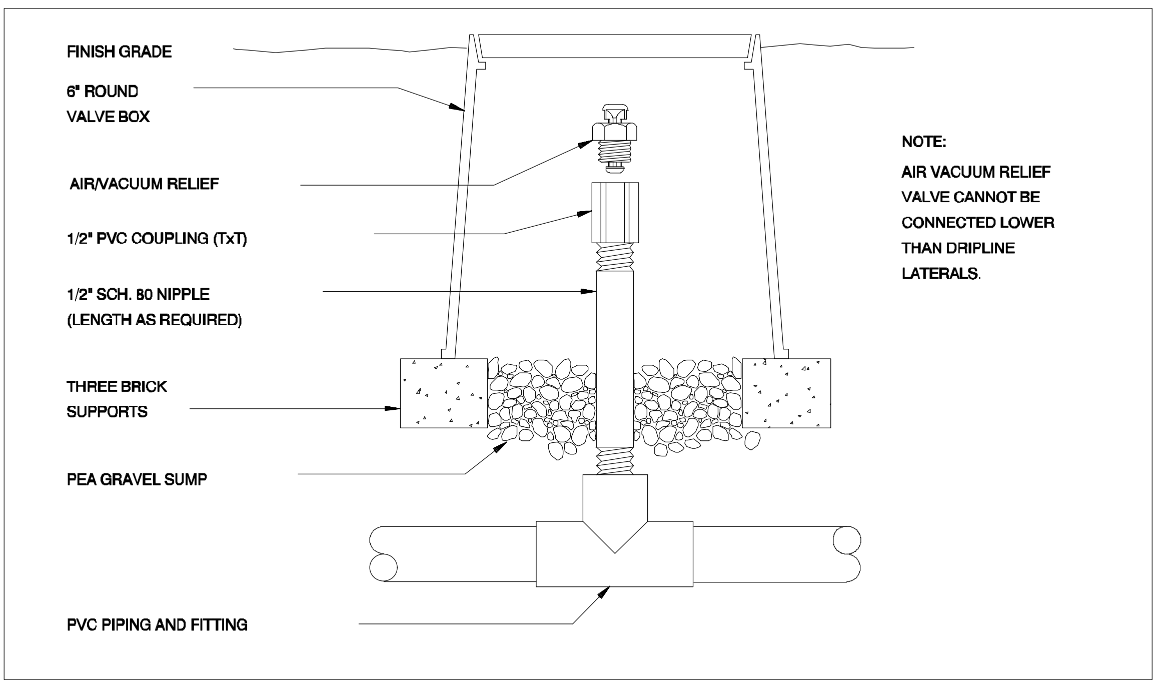

Fig. 6 Air Vacuum Relief Valve in Valve Box with Gravel Sump

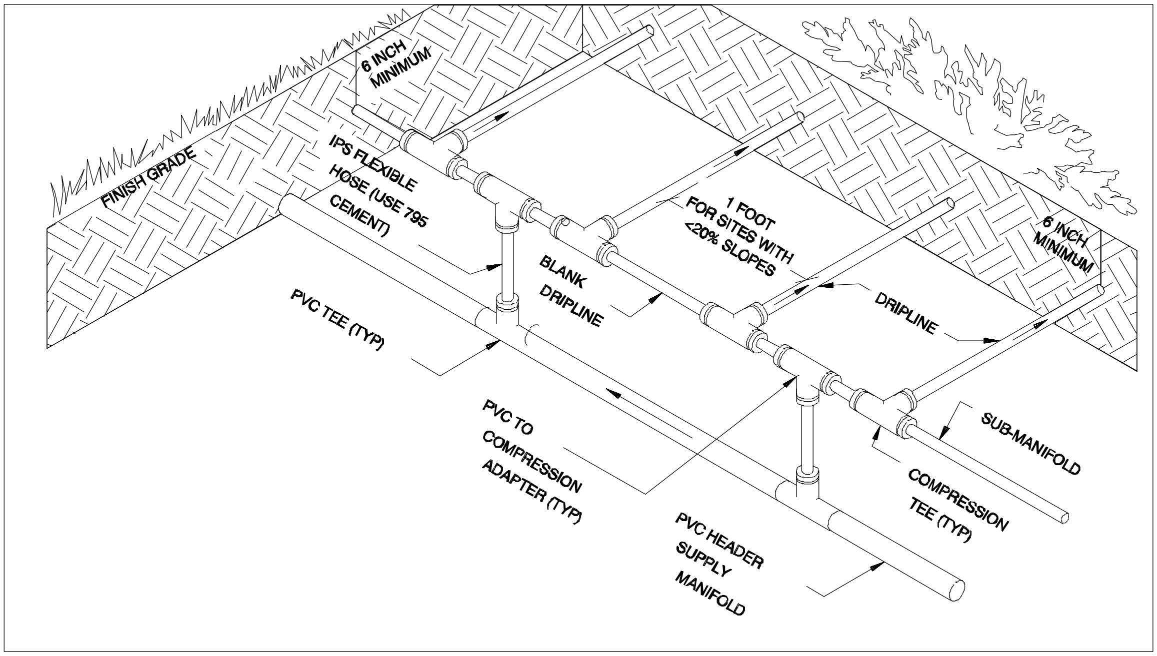

Fig. 7 End Feed Subsurface Drip System Installation with Flush/Sub-Manifold

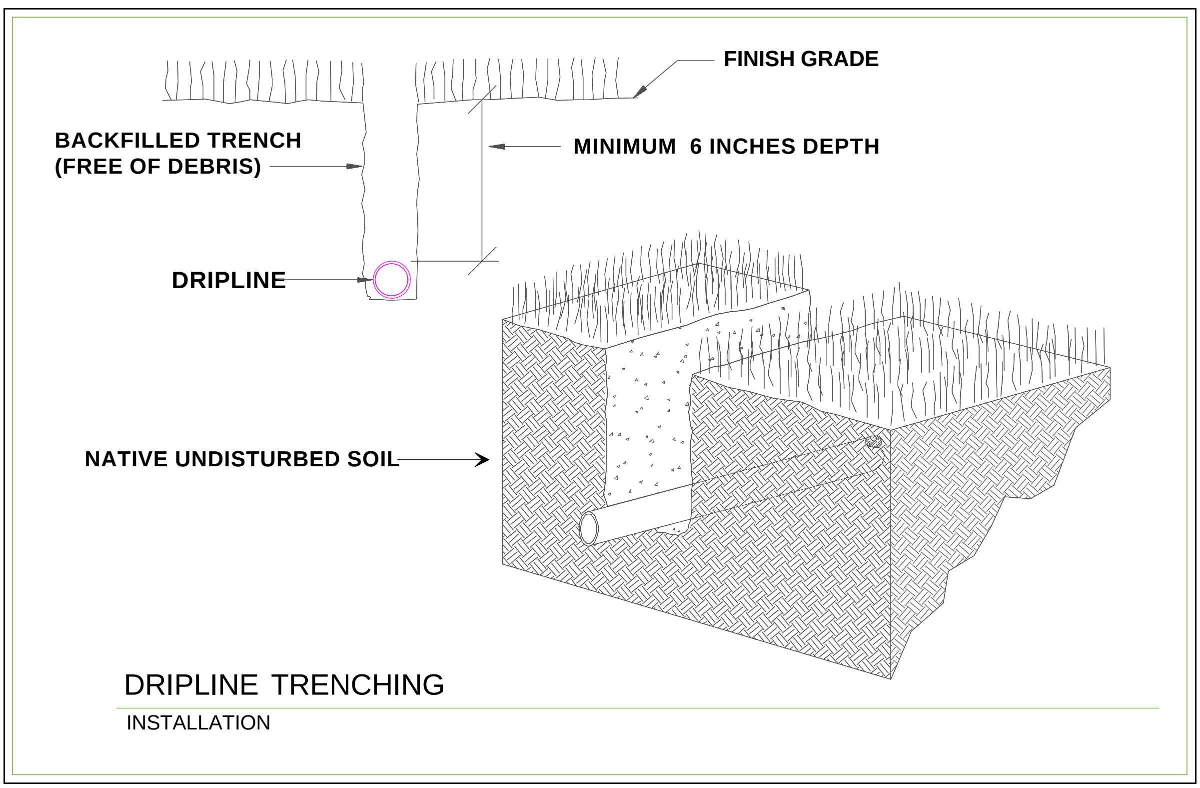

Fig. 8 Shallow Subsurface Drip System Installation

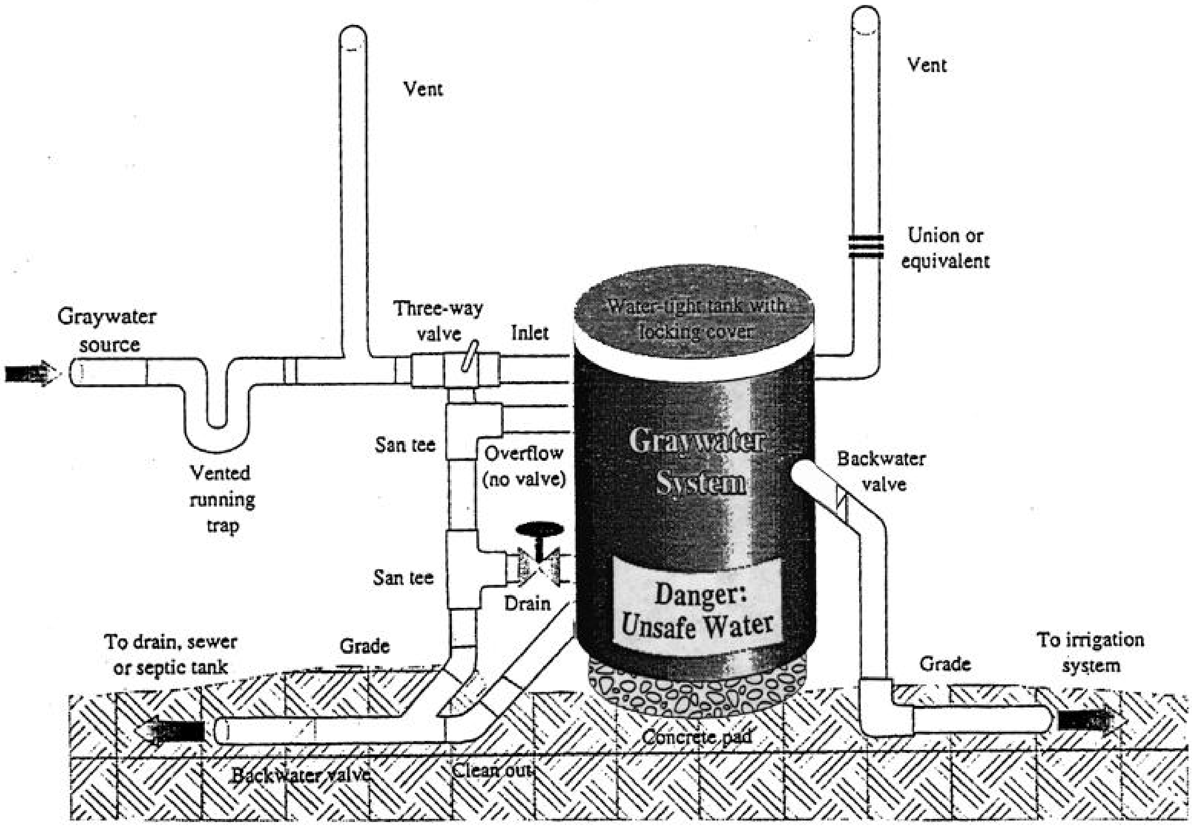

Fig. 9 “Laundry Only” Greywater Tank

APPENDIX C

Tables

TABLE 1

Minimum Design Flows & Septic Tank Sizes for Greywater On-Site Sewage Systems						
	Minimum Design Flow (GPD)			**Minimum Septic Tank Liquid Volume (gallons)**		
Number of Bedrooms	Combined Wastewater System	Greywater System	Laundry Only Greywater System	Combined Wastewater System	Greywater System	Laundry Only Greywater System
1	240	150	45	900	450	40
2	240	150	45	900	450	40
3	360	180	60	900	450	40
4	480	240	75	1000	500	40
each additional	120	60	15	250	125	40
Design flows for greywater systems are reduced by 37.5% for residences with one and two bedrooms and by 50% for residences with 3 or more bedrooms from the minimum design flows for combined wastewater systems listed in Chapter WAC 246-272. The minimum liquid volumes for greywater system septic tanks are reduced 50% from the minimum tank volumes for combined wastewater systems in Chapter WAC 246-272.						

TABLE 2

Wastewater Characteristics Comparison						
Parameter	**Influent * (mean mg/L)**				**Greywater Effluent ** (mean mg/L)**	
	Combined Wastewater	**Blackwater**	**Greywater**	**Greywater as percent of total**	**500 gal septic tank**	**1000 gal septic tank**
BOD_5	260	280	255	63%	101	62
Suspended Solids	260	450	155	39%	47	46
Nitrogen	62	145	17	18%	6.5	7.7
Phosphorous	23	20	25	70%	44	40
Average Flow (gallons)	45.3	15.9	29.4	65%		
* Researchers: Olsson, Wallman, Ligman, Laak, Bennett, Siegrist ; ** Siegrist						

TABLE 3

Subsurface Drip System Design Example: Three Bedroom Residence

Design Element	Design specifics	Comments
Level site (less than 20% slope)		
Soil type 2a	Maximum loading rate: 1.2 gpd/sq. ft	Table V, Chapter 246-272 WAC
Daily design flow (greywater)	180 gpd	Table 1, this document
Emitter spacing (minimum)	1 emitter per square foot	1 emitter = 1 sq. ft trench-bottom of conventional drainfield
Absorption area (minimum)	150 sq. ft.	Design flow / loading rate 180 gpd / 1.2 gpd/sq. ft = 150 sq. ft
Number of emitters	150	1 emitter = 1 sq. ft
Number of doses (minimum)	6	
Frequency of timed doses	Equally-spaced throughout 24 hour day	
Volume per dose	30 gallons	GPD / doses per day 180 / 6 = 30 gallons
Volume per emitter per dose	0.2 gallons	Gallons per dose / # emitters 30 / 150 = 0.2
Volume per emitter per day	1.2 gallons	Gallons / dose / emitter x doses / day 0.2 gallons x 6 - 1.2 gpd
Volume per sq. Ft. Per day	1.2 gallons	1 emitter = 1 sq. ft 1.2 gallons / day / emitter = 1.2 gpd/sq. ft
Flow capacity of (selected) emitter	1.0 gallons per hour	
Duration of dose	12 minutes	Volume / emitter / dose / emitter discharge rate = dose duration 0.2 gallons / dose / 1.0 gph = 1/5 hour or 12 minutes
Timer settings	Pump run 12 minutes every 4 hours	
Dripline spacing (minimum)	1 foot apart	
Dripline layout	6 lines with 25 emitters, spaced 1 foot apart, in parallel rows along topographical contours	

TABLE 4

Estimated Evapotranspiration for Selected Areas in Washington State (inches / week)

West Coast	0.9
Puget Sound Area	1.0
Columbia Basin (East Central)	1.9
Northeastern Washington	1.3

TABLE 5

Plant Factors for Various Plant Types (unitless)	
Plant	**Plant Factor**
Mature Trees	.80
Lawns	.80
Vines and Shrubs over 4 ft diameter	.70
Small shrubs under 4 ft diameter	1.00
Newly Planted Native Plants	.70
Established Native Plants	.40

TABLE 6

Plants that are Not Suitable for Irrigation with Greywater		
Rhododendrons	Impatiens	Dogwood
Bleeding Hearts	Begonias	Primroses
Oxalis (Wood Sorrel)	Ferns	Crape Myrtle
Hydrangeas	Foxgloves	Redwoods
Azaleas	Gardenias	Holly
Violets	Magnolias	Ceodar Celular

TABLE 7

Plants that Would Probably Do Well with Greywater Irrigation		
Sumac	Honeysuckle	Russian Olive
Burning Bush	Rabbit Brush	Mugo Pine
Roses	Italian Stone Pine	Many Native Desert Plants
Rosemary	Oaks	Junipers
Big Basin Sage	Austrian Pine	Sepum
Fringed Sage	Cottonwood	Bearded Iris

TABLE 8

Detergent Comparison

Product Name	P or L	Conductivity	Alkalinity	Sodium mg/L	Boron mg/L	Phosphate mg/L
Ajax Ultra	P	1130	219	292	0.040	11.2
Alfa Kleen	L	25.6	16.8	3.71	<<	<<<
All	P	2030	659	492	0.10	NT
All Regular	L	116	29.8	39.3	<<	<<<
Amway	P	939	310	227	<<	4.00
Ariel Ultra	P	1020	247	280	0.030	10.8
Arm and Hammer	P	2450	1160	572	<<	<<<
Bold	L	46.7	68.6	9.74	<<	<<<
Bonnie Hubbard Ultra	P	1560	617	377	0.036	<<<
Calgon Water Softner	P	1290	345	359	<<	22.9
Cheer Free	L	307	80.3	94.7	<<	<<<
Cheer Ultra	P	710	149	171	0.076	<<<
Chlorox 2	P	2880	1430	672	11.2	<<<
Dash	P	1060	482	238	2.14	<<<
Dreft Ultra	P	737	328	189	9.75	<<<
Downy Fabric Softener	L	6.37	NT	<	<<	<<<
Ecocover	L	132	63.7	24.3	<<	<<<
ERA Plus	L	102	15.3	26.3	<<	<<<
Fab Ultra	P	1140	199	443	<<	21.7
Fab 1-Shot	Pkt	501	09	109	<<	5.26
Fresh Start	P	510	106	132	0.026	8.28
Gain Ultra	P	792	300	180	0.058	<<<
Greenmark	P	1690	568	395	<<	1.67
Ivory Snow	P	258	219	70.8	<<	NT
Oasis	L	89.6	16.2	<	<<	<<<
Oxydol Ultra	P	1030	501	272	11.3	<<<
Par All Temperature	P	2350	431	529	0.049	2.67
Purex Ultra	P	1010	278	231	<<	<<<
Sears Plus	P	2500	1200	635	<<	<<<
Shaklee	L	19.0	12.1	6.48	<<	<<<
Shaklee Basic L	P	1030	285	230	<<	<<<
Snuggle Fabric Softener	L	2.60	NT	<	<<	<<<
Sun Ultra	P	1490	653	335	<<	1.58
Surf Ultra	P	989	302	249	<<	13.7
Tide with Bleach	L	329	58.3	95.0	2.30	<<<
Tide Regular	L	291	61.2	93.8	0.030	<<<
Tide Ultra	P	959	236	243	0.098	10.7
Valu Time	P	1650	460	371	0.034	1.79
White King	P	266	165	74.0	1.83	NT
White Magic Ultra	P	1140	194	273	0.035	18.5
Wisk Advanced Action	L	221	72.4	56.8	7.41	<<<
Wisk Power Scoop	P	1160	360	319	<<	9.77
Woolite	P	1040	22.3	239	0.17	<<<
Yes	L	42.5	10.3	6.40	<<	<<<
Tap Water	N/A	317	118	42.7	0.042	<<<
Distilled/Deionized Water	N/A	2.03	3.78	<	<<	<<<

Legend: P = powder; L = liquid; < means less than the sodium detection limit of 1.0 mg/L; << means Less than the boron detection limit of 0.025 mg/l; <<<means Less than the phosphate detection limit of 1.2 mg/l; NT means Testing of sample not possible.

APPENDIX D

Greywater Reuse

Characteristics of Greywater

Drainfield sizing standards for Greywater systems assume that "residential strength" greywater will be delivered to the drainfield (see Definitions). Residential waste strength actually varies according to individual circumstances, with septic tank capacity, temperature and choice of household products, etc.

Soil loading rates in Chapter 246-272 WAC are suitable for effluent with the following maximum values or less**:** $BOD_5 \leq 230$ mg/L, TSS ≤ 150 mg/L and Total Grease and Oil (G &O) ≤ 50 mg/L (see "Definitions" in Appendix for explanation of these terms). See Table 2 for a comparison of wastewater characteristics.

Owners of greywater systems who experience performance problems should sample greywater to verify that waste strength is not too high. Homeowner can reduce waste strength by installing screens on kitchen sink drains, by reducing disposal of fats, greases and oils and avoiding the use of disposals.

Safety Issues

Greywater can potentially contain toxic chemicals and pathogens such as parasites, infectious bacteria and viruses and exposure to it can pose a risk to human health. For that reason the only reuse application permitted for greywater is subsurface landscape irrigation. Greywater should not beused for lawn sprinkling or for watering vegetable gardens (fruit trees are OK).

Homwowners who wish to resue greywater for subsurface landscape irrigation should excercise caution and follow standard sanitary procedures when digging or planting in the vicinity of a greywater drainfield or servicing greywater distribution systems.

Cross connection control. Some periodic flushing of soils to reduce salt build-up or suppliments of fresh water to irrigated plants may be necessay. No direct connection between a greywater irrigation system and the potable water supply is allowed without an approved form of backflow prevention.

Climate

Local climate is an important parameter in designing greywater subsurface irrigations systems. Average annual precipitation, local evapotranspiration and frost protection should be considered. See Table 4 for some estimated evapotranspiration rates in Washington state.

Agromomic Issues

The design of a greywater subsurface irrigation system requires consideration of the following parameters:

The amount of greywater available to irrigate with. For design purposes the minimum design flows in Table 1 must be used to determine the size of the irrigation field / drainfield. These are resonable estimates but are based on the number of bedrooms in a residence and actual flows may vary.

The amount of landscape that can be irrigated. This is calculated based on area for lawns and other ground covers or based on the number of plants for trees and shrubs. See design examples below.

The nutrient and water needs of the plants to be irrigated. The nutrient needs of the irrigated plants should be considered and some plants may require nutrient suppliments. For design purposes the water needs of the irrigated plant at maturity should be used. It is recommended that homeowners who wish to irrigate with greywater consult with a nursery, landscape architect or local cooperative extension office for more information. See Table 5 for plant factors that reflect relative water needs of various plants.

The greywater compatability of the plants to be irrigated. Some plants are better suited than others for irrigation with greywater. Generally, shade-loving and acid loving plants **do not** like greywater. These type of plants are typically found in forests where acid soils predominate. See Tables 6 and 7 for some plants that are or are not greywater compatable.

The root depth and root zone area of the plants to be irrigated. The root depth and root zone area of the plants to be irrigated is an important consideration and will vary for different types of plants. Irrigation is more efficient if greywater is delivered to the zone where plants can best use it. Consult with a nursery, landscape architect or local cooperative extension office for more information.

Irrigation efficiency/ method of distribution. The type of distribution system impacts irrigation efficiency. Generally, pressurized distribution is more efficent than gravity and subsurface drip systems are the most efficient. Irrigation efficiency also depends on soil type and climate. Consult with a nursery, landscape architect or local cooperative extension office for more information.

Soil Type and Salts. In areas with very low rainfall it may be advisable to periodically flush salts from the soil in the irrigated area. Flushing is recommended for soils with a high percentage of clay or in areas with less annual precipitation than 20 inches per year. Sandy soils are less vulnerable to damage by salts in greywater than clay soils because they drain better. Be aware that some harmful effects are not always visible immediately and may take one or two years to appear. Discontinue using greywater if signs of stress in irrigated plants are observed.

Design Equations and Examples:

In order to design a greywater irrigation system/on-site sewage system first the amount of landscape that can be irrigated must be calculated, and this must be reconciled with the minimum drainfield size based on greywater design flow and soil type. The minimum drainfield size must always be maintained. See the equations and examples below.

To calculate the area that can be irrigated the following equation can be used:

$$A = IE \times [GP / (ET \times PF \times 0.623)]$$

Where:
A = Area that can be landscaped (ft^2)
IE = Irrigation Efficiency, unitless, always less than 1.0 (see note below)
GP = Estimated Greywater Production (gallons/week)
ET = Evapotranspiration * (inches/week)
PF = Plant Factor ** (relative water need of plant)
0.623 = Conversion Factor ***

Irrigation efficiency (IE) is the percentage of irrigation water avoidable for consumptive use by the plant material. This will depend on the method of distribution and local conditions. Consult with a local nursery, landscape architect or cooperative extension agent to estimate this value.
* See Table 4 for some estimated evapotranspiration rates in Washington state.
**See Table 5 for some plant factors for various types of plants

To calculate the number of plants that can be irrigated the following equation can be used:

$$RG = [(0.623 \times RZA \times PF \times ET) / IE]$$

Where:
RG = The required greywater to be applied (gallons per plant per week)
0.623 = Conversion Factor (1 inch of water applied over 1 ft^2 = .623 gal)
RZA = Root Zone Area of the plant to be irrigated at maturity (ft^2)
PF = Plant Factor (relative water need of plant – unitless see Table 1)
ET = Evapotranspiration (peak summer value/inches per week-see Table 4)
IE = Irrigation efficiency for local area (unitless, always less than 1.0)

The root zone area (RZA) of a plant will expand as a plant matures, but roughly corresponds to the area within the drip line, or the area of the plant canopy. To determine this value in square feet measure or estimate the diameter (d) of the plant canopy in feet (at maturity), square it, and multiply that value by 0.785 (the area of a circle of diameter “d” is $A = Iid^2/4 = d^2 \times 0.785$).

Design Example 1:

A family living in a 4 bedroom home with laundry facilities in Richland produces about 240 gallons of greywater per day (about 1680 gallons per week). Evapotranspiration during the peak irrigation season there is estimated to be about 1.9 inches per week. They wish to irrigate a lawn (high water using, plant factor is 0.8). The area they can irrigate is therefore:

A = GP / (ET x PF x 0.623)
A = 1680 / (1.9 x 0.8 x 0.623)
A = 1774 square feet

The soil type on the lot is a silt loam (Type 5), from Chapter 246-272 WAC maximum allowable loading rate is 0.45 gpd/ft^2 . Minimum required drainfield area is 240 gpd/0.45 gpd/ft^2 = 533 ft2 (which is less than the actual area that will be irrigated therefore this sytems meets the requirements of Chapter 246-272 WAC.

Design Example 2

A homeowner wishes to plant a row of lilacs (Syringa vulgaris). A mature lilac shrub will have a canopy diameter of up to 10 feet. The plant factor is 0.7 and for design purposes assume the root zone area is the same as the canopy. Peak summer evapotranspiration in Spokane is estimated to be 1.75 inches per week and the irrigation efficiency is about 0.85. The greywater required per lilac shrub per week is:

RG = [(0.623 x RZA x PF x ET) / IE]
= (0.623 x 10^2 x0.785 x 0.7 x1.75) / 0.85
= 70.5 gallons per week per shrub

The homeowner lives in a 3 bedroom home so from Table 1, greywater produced will be about 180 gpd or 1260 gallons of greywater per week. If he irrigated only lilacs he would be able to plant about 1260 / 70.5 = about 18 Lilacs.

The soil type on the lot is a sandy loam (Type 4, from Chapter 246-272 WAC maximum allowable loading rate is 0.6 gpd/ft^2 . Minimum required drainfield area is 180 gpd / 0.6 gpd/ft^2 = 300 ft2. Mature lilacs will occupy an area equal to a 10 ft. diameter circle or .785 x 10^2 = 78.5 ft. 18 lilacs will therfore occupy about 18 x 78.5 = 1414 ft2. This is a greater area than the minimum required under on-site rules, therefore this system can be permitted.

Household Chemicals / Detergents

The type of household chemicals used directly impacts the health of plants irrigated with greywater. Some household products that can be detrimental to plants are chlorine bleach and drain cleaners, solvents, insecticides and paint.

Detergents

The following information has been adapted from an informational handout (Greywater and Your Detergent) that was developed by the City of Tucson, Arizona in 1993:

The choice of laundry detergent can have a major impact on the health for landscaping plants. Most hand soaps and shampoos will not damage plants at low residential concentrations. Laundry detergents can adversely impact plants and should be carefully selected. Among the chemicals that are commonly found in many laundry detergents are sodium and boron. Powdered soaps typically contain sodium compounds which are detrimental to plants and soil. Some laundry detergents also contain boron, which is toxic to plants except in very minute quantities. Cleaners and laundry soaps to *avoid* are:

- Bleaches and fabric softeners
- Detergents with whiteners, softeners and enzymes
- Detergents which include boron, borax, chlorine, bleach, peroxygen or sodium perobate, petroleum distillate or alkylbenzene or sodium trypochlorate.

A study of laundry detergents was sponsored by Tucson Water in 1992. It was based in part on research conducted by Pima County Extension Service and prepared by the Office of Arid Land Studies in cooperation with the soil Water and Plant Analysis Laboratory, University of Arizona. The study measured the following constituents of a number of brand name laundry detergents: Alkalinity, Boron, Sodium, Conductivity and Phosphate (see definitions).

A Note About Chlorine — Although chlorine in bleach and detergents is generally expended in the washing process, some may be left in the greywater that reaches plants. Chlorine should not be used in the garden because it may substitute for similar nutrients, blocking normal metabolic processes. The addition of chlorine to water used for irrigation should be kept to a minimum.

Tucson Water Detergent Study

This study was based in part on research conducted by the Pima County Extension Service, and was prepared by the Office of Arid Land Studies, in cooperation with the Soil, Water and Plant Analysis Laboratory, University of Arizona, and sponsored by Tucson Water.

All the detergents and related clothes-washing products were purchased in Tucson during May, 1992. The amounts used were based on the manufacturers' recommended levels for a cool to warm water wash in a top loading machine. Distilled waster was used as a source to minimize the effect of widely-varying salt and mineral levels in tap water.

See Table 8 for the results of the study. The list is presented in alphabetical order and is intended a basis for comparison only. No endorsement of any product is intended.

Summary —

Choose your detergent and clothes-washing products keeping in mind that it is better for your plants and soils to have a low alkalinity, boron, conductivity, and sodium content in the water. Personal preference may affect your choice of products, since higher levels of these constituents may add to their cleansing ability.

Appendix E

Additional Reading Materials

1. Siegrist, R., Management of Residential Greywater, Small Scale Management Project, University of Wisconsin, Madison Wisconsin, March 1978
2. Assessment of On-site Graywater and Combined Wastewater Treatment and Recycling Systems, National Association of Plumbing-Heating-Cooling Contractors and Enviro-Management & Research, Inc., August 1992
3. Graywater Pilot Project, Final Report, City of Los Angeles Office of Water Reclamation, November 1992
4. EPA Design Manual, On-site Wastewater Treatment and Disposal Systems, EPA # 625/1-80-012, Oct. 1980
5. Design Standards for Large On-site Sewage Systems, Washington Department of Health, December 1993
6. Graywater Guide, California Department of Water Resources, December 1994
7. Drip Irrigation for Every Landscape and All Climates, Robert Kourik, 1992
8. Geoflow Subsurface Dripline Design and Installation Manual for Small Systems, May 1997
9. The Building Professional's Graywater Guide, Art Ludwig, 1995
10. Create an Oasis With Graywater, Art Ludwig, 1994
11. Domestic Greywater Reuse: Overseas Practice and its applicability to Australia, Urban Water Research Association of Australia, March 1994
12. Guidelines for Water Reuse, Camp Dresser & McKee, U.S. EPA publication No. EPA/625/R-92/004, Sept. 1992
13. Tucson Water (City of Tucson) Informational Handout, March, 1993